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THE PHYSICAL GEOGRAPHY OF NEW YORK.

BY

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PART IV.—THE INFLUENCE OF THE GLACIAL PERIOD UPON TOPOGRAPHY.

INTRODUCTION.—When the Geological Survey of New York was undertaken, considerably more than half a century ago, the belief was current that the State had been overrun by great floods of water which had strewn the surface with the various deposits of boulders, gravel and clay which are so noticeable throughout the State.* Then came the glacial theory of Agassiz, at first vigorously opposed, but gradually accepted, until at present it is all but universally adopted as the real explanation of the phenomena formerly ascribed to the flood.

The farmers of the State till a soil brought to their land by an ice sheet of vast proportions, greater by several times than that now covering the great continental island of Greenland with 500,000 square miles of ice. They remove from their fields the boulders brought by the ice from the north, perhaps from even beyond the confines of the country, and they look upon a landscape modified, or perhaps even moulded, or entirely made, by this ice sheet. The lakes, the swamps, the gorges and the waterfalls have come to be what they are because of this glaciation; and the economic development of the State has depended in very large measure upon the

* See Eaton, Am. Journ. Sci., XII, 1827, 17–20; Dewey, Am. Journ. Sci. XXXVII, 1839, 240–242; Same, XLIV, 1843, 146–50; Emmons, Geol. of N. Y., Second Dist., 1842, 422–427; Hall, Same, Fourth Dist., 1843, 318–341; Mather, Same, First Dist., 1843, 158–228; Vanuxem, Same, 3d Dist., 1842, 212–224, 244–247; Lloyd, Quart. Journ. Geol. Soc., XXXII, 1876, 76–79.

visit of this ice sheet. Without this visit the industries, cities and people would have been very different.

Much interest has been aroused in the problems presented for solution by this latest great physiographic factor in the development of topography. Upon these problems much work has been done; but much remains still undone. New York State, though supporting a geological survey with some continuity for more than half a century, the results of which in a single direction have been of the best, has almost totally neglected this important subject. Hence, barring a few scattered individual efforts, and a single Government publication, almost nothing has been done to put before the people of the State the facts concerning their own environment. The farmer who would know the cause for his soils, or the teacher who would learn the meaning of the hills surrounding the school, or of the gorge or lake near by, can find no place in which to look for an answer to his queries. This stands to the discredit of New York State.* This discussion is bound therefore to be very inadequate because little is known.†

Before the Glacial Period.—Without careful and wide-extended study it would be impossible to tell in detail what the condition of New York was before the glacial period. This much is certain, however, that most of the larger features of land-form were then much as they are now. There was then an Adirondack Mountain mass, a Catskill Mountain group, and a dissected plateau in western and central New York; and each of these sections was then cut into hills and valleys, very much as they are now. The larger stream valleys, such as the Hudson, the Mohawk, and the Susquehanna, and also most of the smaller tributaries of these, then existed, although the details of stream course were in many instances very different from the present. Some rivers now flow into different valleys from those which they formerly entered, and still more flow in different parts of the old valleys, perhaps upon one side of the former course. The ice has planed down some of

* What is said of glacial geology applies equally to physiography in general, and also almost as fully to economic geology. The paleontology and stratigraphy are well known in some parts, but there is no adequate discussion of the salt, the iron, the oil and gas and the several mining industries of the State. In an intelligent and wealthy community such a condition should not exist.

† For statement of some of the principles of glacial geology reference may be made to Wright's Ice Age in North America; Wright's Man and the Glacial Period; Geikie's The Great Ice Age; and Salisbury's discussion in the Ann. Rept. of the State Geologists of New Jersey, for 1891, 35–108.

these hills to slightly lower levels than formerly, and rounded off still others, while the valleys have in many places been clogged, or in some cases even entirely filled, with glacial deposits.

But the most marked difference between the New York of to-day and the preglacial New York is in the introduction of numerous lakes. One could not safely assert that there were then *no* lakes in the State; but upon every physiographic argument that can be made, the existence of any but the smallest lakes seems highly improbable. Lakes must have a cause, and lake-making causes had apparently not been in operation extensively immediately before the glacial period. Therefore, the lakes, Champlain, Ontario, Erie, Chautauqua, the Finger Lakes, and the thousands of smaller ones, were probably not present. Of the larger number of these it may be stated positively that they did not then exist, for their cause is certainly glacial action.

At some time before the glacial period, the general altitude of the State was very different, being considerably higher above sea-level. Whether this was true at the very time when the ice encroached upon this region cannot be so certainly stated, though there is much reason for believing that, even as the ice gradually advanced, the land was standing higher above the sea than now.

Notwithstanding these differences between the present and past, could we have an accurate model of New York State upon a large scale, representing the conditions of preglacial times, one would have no difficulty in recognizing the *general* topography of the region in which he dwells. The general elevation might be higher than at present, and some of the hills higher above the valley bottoms. Some valleys may now be deeper than formerly; and, as a result of the glacial deposits, some now absent would then be present, and some now existing would not appear upon the model. The course of some of the rivers would be different, and most of the gorges, waterfalls and lakes would not be found, the site of the lakes being then valleys occupied by running water. Probably, also, the coast line was different in an important way. If the land were then higher, the coast line must have been somewhere to the eastward of its present position. So it follows that there were many differences, some of them of a very striking kind, but not so many as to make the general topography of the land unrecognizable.

THE ADVANCE OF THE ICE SHEET.—Over this land the ice front slowly advanced, coming on irresistibly, and fed from some centre in the far north, evidently in the vicinity of the Labrador Penin-

sula, from which the ice radiated outward in all directions, as the Greenland ice sheet of to-day radiates from a centre somewhere within that great ice-covered land area. Why it came cannot now be stated; nor can we say when it began, nor how long it stayed, nor when, nor why it went. Speculations upon this point are abundant, but they have been of little value in reaching definite and well-proved conclusions. The *fact* of the coming and going is all that can be stated with positiveness in this connection.

FIG. 1.—TO SHOW PROBABLE EXTENT OF AMERICAN ICE SHEETS (CHAMBERLIN IN GEIKIE'S GREAT ICE AGE).

As the wall of ice gradually moved southward, involving States at present temperate in climate, and before that even warmer than now, there must have been a refrigeration of climate, partly due to the *presence* of the ice, and partly to the causes upon which the formation of the great continental glacier depended. Then, upon the high mountains, the winter snows must have lasted longer and longer into the summer, until the protected valleys held some of the snow throughout the entire season. At this time valley glaciers, somewhat like those of the Alps, probably appeared in the Adirondacks and Catskills, growing larger as time passed, and finally adding their supply to that of the great glacier from the north. This rose higher and higher upon the mountain sides, until, finally, the highest peaks of the Adirondacks and Catskills were submerged in the onmoving flood of ice, and all of New York State, with the possible exception of a small tract in the extreme western part, was transformed to a great ice plateau like that of Greenland to-day. From Labrador to Pennsylvania no land appeared above the ice covering, whose depth was certainly greater than a mile in some places. At present no similar ice sheet exists, unless possibly the one in the South Polar regions.

With the advance of the ice, plants were exterminated, and animals either exterminated or driven out to the southward. For a long time these conditions lasted, though how long, no one can

now say; and year by year the ice advanced through the valleys and over the hills and even the mountain tops. At first it swept

FIG. 2.—TO SHOW APPROXIMATE EXTENT OF ICE SHEET IN EASTERN UNITED STATES. "MORAINE OF SECOND GLACIAL EPOCH" SHOWN BY HEAVY SHADING (CHAMBERLIN).

off the soil and rock, dragging it southward, and grinding it by rubbing particle against particle, or against the rock over which the glacier was slowly gliding. Valleys were deepened somewhat and

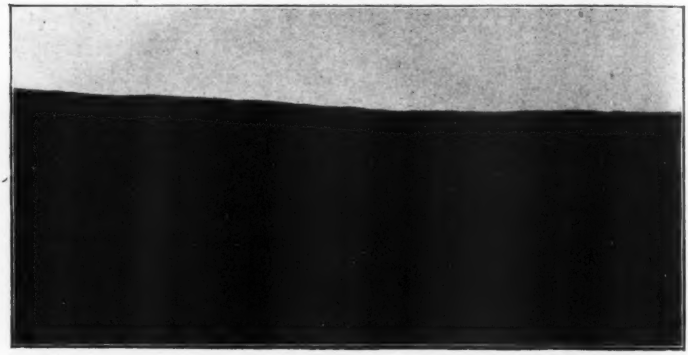

FIG. 3.—SURFACE OF THE GREENLAND ICE PLATEAU (PHOTOGRAPH BY J. O. MARTIN).

hills scoured by this great force of erosion, the hills losing some of their height and being rounded. The pebbles that the ice held, and the bed rock over which they were dragged were both grooved,

FIG. 4.—A GLACIALLY SCRATCHED PEBBLE (PHOTOGRAPH BY U. S. GEOL. SURVEY).

or scratched, and polished; and at all times during the stay of the ice, the glacier contained in its mass a load of rock fragments,

FIG. 5.—GLACIAL SCRATCHES ON BED ROCK (CALVIN, IOWA GEOL. SURVEY).

varying in size from boulders to clay particles, all slowly journeying southward with the ice, and being ground as they went.

At the margin, land appeared above the ice, at first as isolated hills, reaching above the ice surface, as the mountain peaks of Greenland project above this great glacier, forming the nunataks of that region; then, nearer the margin, as ranges of hills separat-

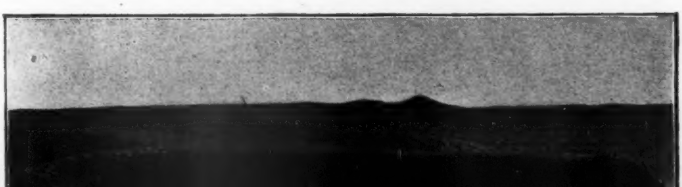

FIG. 6.—A NUNATAK RISING ABOVE THE GREENLAND ICE PLATEAU, CORNELL GLACIER (PHOTOGRAPH BY J. O. MARTIN).

ing projecting tongues of the glacier front,—small valley lobes projecting further southward along the valleys. The margin was evidently serrated or lobate, and the reason for the margin was that there the ice supply just equalled the ability of the sun to melt it.

So, along this margin, as along the margin of all glaciers on the land, there were vast floods of water poured upon the hill sides and gathered into the valleys. Here was supplied to river valleys the rainfall of other drainage systems far to the north. Some, falling where it now escapes into the Arctic waters or the St. Lawrence system, then passed on and entered the Susquehanna, or further west, the Upper Allegany, whence it was led to the Gulf of Mexico. As a result, many small stream valleys then carried large volumes of water. Sometimes the front of the ice was not in a valley sloping away from it, but toward it, and then, in such north-sloping valleys, glacial lakes were ponded back in places where now no lakes exist. The records of these are abundant.* In the north-sloping valleys this water was iceberg laden, and everywhere, where

FIG. 7.—LAND MARGIN, CORNELL GLACIER, GREENLAND, SHOWING DEBRIS-LADEN ICE LAYERS NEAR BASE, AND TERMINAL MORAINE IN FOREGROUND (PHOTOGRAPH BY J. O. MARTIN).

it started from the ice, was ice-cold, so that, flowing into more temperate latitudes, it must have produced a very important influence upon the climate of parts of the South, especially along the Mississippi Valley, nearly all of the headwaters of which were supplying this ice-derived water.

* See Tarr (Part III of this series), Bull. Am. Geog. Soc., XXX, 1898, 44.

Not merely was *water* supplied to the streams, but much rock material also; for this too was constantly moving on with the ice to the place of melting. Some of this entered marginal lakes, forming lake deposits in places where now no lakes exist and some passed

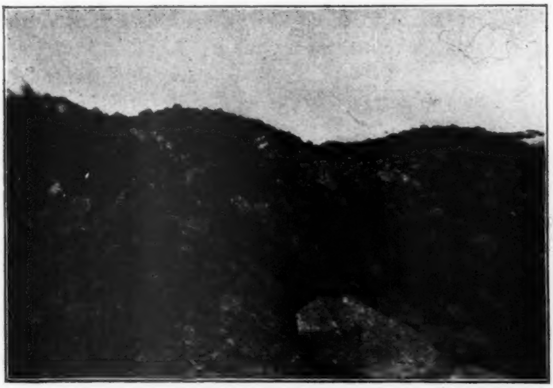

FIG. 8.—BOULDERY TERMINAL MORAINE AT MARGIN OF CORNELL GLACIER, GREENLAND (PHOTOGRAPH BY J. O. MARTIN).

off in rivers, forming various types of river deposits,* often in valleys in which now the rivers are not depositing sediment. Not all of this rock load could go off in the streams, but much fell to the base of the ice, or remained in its place beneath the glacier. If the front of the glacier remained for a long time in approximately one

FIG. 9.—NEARLY BOULDER-FREE MORAINE IN PENNSYLVANIA (LEWIS).

place, as it did year by year, this dumping of rock fragments continued until perhaps a very considerable accumulation was made,

*See Tarr (Part III of this series), Bull. Am. Geog. Soc., XXX, 1898, 43 and 45.

forming a moraine. The former position of the ice front is now traced by these moraine hills and ridges, which extend across the country as indicated in the accompanying maps. The moraine formed upon the land is quite like that now being made at the margins of existing glaciers.

While throughout most of New York State the southernmost stand of the glacier front was upon the land, it is quite possible that the front in the Long Island region was at one time in the sea, as it certainly was farther east. In this case the glacial deposits were then dumped in the ocean near the ice margin, or such fine parts as could be floated away were removed by currents, to which transportation was added that done by the numerous icebergs which must have broken from the glacier front.

FIG. 10.—TO SHOW GENERAL EXTENT OF ICE IN NEW YORK. SOUTHERN LIMIT OF SHADING MARKS THE POSITION OF THE OUTERMOST TERMINAL MORAINE OF LEWIS AND WRIGHT, THE HEAVY SHADING THE SO-CALLED "MORAINE OF THE SECOND GLACIAL EPOCH" (CHAMBERLIN).

THE RETREAT OF THE ICE SHEET.—In time the conditions which gave rise to the Glacial Period began to change, and the ice supply was no longer able to maintain the ice front at the southernmost limit.* Then this line was abandoned and the ice front slowly melted back again, uncovering the country over which it had formerly advanced. This retreat or recession of the ice was intermittent, for we find evidence that at certain places the ice halted, and the front remained long enough to build terminal moraines, or *moraines of recession*, closely resembling that formed at the outermost terminus. Thus, for instance, after having passed well down into

* No attempt is made here to consider the question whether there was more than one advance of the ice, partly because it is a question still open and in controversy, but chiefly because its bearing upon the physiography of New York is not known.

Pennsylvania,* the ice halted for a long time along the line of the so-called "moraine of the Second Glacial Epoch," which is shown for central New York upon the map.† Numerous other halts were made, as shown by the map of the western New York moraines.‡

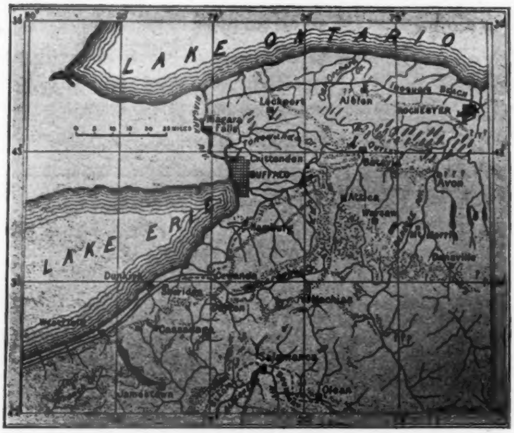

FIG. 11.—MAP OF MORAINES IN WESTERN NEW YORK. DIRECTION OF ICE MOVEMENT SHOWN BY ARROWS. DRUMLINS MARKED SOUTH OF ROCHESTER. OLD BEACH LINE SHOWN ALONG ERIE AND ONTARIO SHORES (LEVERETT).

Each of these halts is marked by a more or less well-defined moraine, formed at the terminus of the receding glacier. During the time of formation of these moraines the conditions at the glacier margin must have been closely like those described for the southernmost margin. Between these successive moraines the glacial recession must have been relatively rapid, for the front did not stand in any one place for a long enough time to permit the dragging of *débris* to the margin in sufficient quantity to accumulate morainic hills.

Thus it is seen that in New York State the ice front first *advancea* across the surface, visiting each part of the State, though the record of what it then did was mostly destroyed by the continued advance over all points excepting the deposits at the southernmost margin. Then this was followed by the ice *withdrawal*, during which each

* Lewis, Proc. Am. Phil. Soc., XX, 1882–3, 662; Proc. Am. Assoc. Adv. Sci., 1882, XXXI, 389–98; Am. Journ. Sci., 1884, Ser. III, XXVIII, 276–285; Report Z, 2nd Geol. Survey Pa.; Wright, Bull. 58, U. S. Geol. Survey, 1890.

† Chamberlin, Trans. Wis. Acad. Sci., IV, 1876–7, 201–234; Am. Journ. Sci., 1882, XXIV, Ser. III, 93–97; 3d Ann. Report, U. S. Geol. Survey, 1883, 291–402.

‡ Leverett, Am. Journ. Sci., 1895, L, Ser. III, 1–20.

part of the State was visited by the glacier front, this time, however, leaving a record of its visit which can now be read, especially at those places where the ice front lingered for a while and built moraines.

Thus it came about that moraines were formed at various points in New York, and that all over the State, every here and there, the water from the melting ice made deposits of gravel and clay derived from the glacier. These deposits, being made by water, are assorted and stratified. All glacial deposits are called *drift*, a name inherited from the time when they were explained as flood deposits. These

FIG. 12.—CROSS-BEDDED STRATIFIED DRIFT, ITHACA, N. Y. (PHOTOGRAPH BY C. S. DOWNES).

water deposits are called *stratified drift*, or sometimes *modified drift*, because they are not deposits direct from the ice, but modified through the intervention of water. Naturally the stratified drift is most commonly found in valleys, for it was here that the water went; but it is not *confined* to the valleys, for many a stream from the ice top, or from beneath the glacier, reached the edge of the glacier upon a hillside, or even, in some cases, upon a hilltop. Not only does the position vary, but the depth also, though, in general, the stratified drift is deepest in the valleys, being in some cases two or three hundred feet deep.

Held firmly in the ice, and dragged along beneath it, were rock fragments, bits of clay, pebbles, and great boulders, all journeying

southward; and, side by side, were coarse and fine fragments. As the ice was withdrawing, and these rock fragments were loosened by melting, some of them went away in the water to be deposited as stratified drift, but much fell directly to the ground or stayed in its place beneath the glacier. This drift was not definitely assorted, but was made of clay, sand, pebbles and boulders mixed indiscriminately together, for the ice was able to carry a large boulder as well as a bit of clay, a thing which water under ordinary conditions cannot do. Those deposits from the glacier form the characteristic soil of New York, particularly of the hillsides and hilltops, and, in places, of the valley bottoms. This is known as *till* or *boulder clay*. Thus it happens that a farm in one part may be bouldery and clayey, in another part clayey without boulders, and still elsewhere either sand or gravel. In each of these cases there was a cause, which, by careful study, can often be determined, though sometimes this is impossible because of the complexity of conditions attending the withdrawal of the ice, the full evidence of which is sometimes lacking. Many a resident of New York has been puzzled to know the reason for these variations.

With the withdrawal of the ice the conditions were again made favorable for the existence of animal and plant life upon the surface. Foot by foot the country was relieved of its ice blanket, and slowly the soil left by the glacier began to be made to nourish plant life and to furnish a dwelling place for animals. At first skirting the ice front there must have been strips of land entirely without vegetation. Then came the light-seeded grasses and small plants, and then the forest. During this bare condition the rain fell, and gathering into mud-laden rills, washed much of the imported soil away, as it now does on the roads and ploughed fields; and this sediment was added to the stratified drift from the glacier.

There is good reason to believe that the rains were perhaps heavier then than now, for the presence of the ice to chill the moisture-laden winds from the south, and the large amount of vapor that would be produced from the floods of the glacier-supplied waters, would bring about conditions favoring heavier rain. At this time, also, where the slope was sufficient for the removal of the sediment, the streams must have had more power to cut than now; and probably much of the gorge cutting in central New York was accomplished during this time,* when there was probably more water and when certainly the water that fell upon the surface flowed away more quickly, in the form of floods, than it did later

* Tarr, Amer. Geol., XIX, 1897, 135.

when its run-off was retarded by the forests. Also, at this time the streams had more sediment to serve as cutting tools than later when the soil was held in place by the roots of the forest trees.

What happened among the mountains with the *advance* of the glacier probably also happened with its withdrawal. The last stage of glacier retreat in Greenland, upon land from which the glacier has just withdrawn, is that of local valley glaciers. The same was true in New Hampshire and Maine; and, no doubt, when studies of the Adirondacks have been made, evidence of local valley glaciation will be found there in many places. At present no evidence of this has been put forward, and it therefore stands merely as an inference of probability.

MORAINES.—*Topography.*—In many places where the ice front stood for only a very short time, the moraine which accumulated at the margin is not very deep. Sometimes it is merely a tract of unusually numerous boulders; but in many places so much has been

FIG. 13.—THE TERMINAL MORAINE, WEST DANBY, IN CAYUGA VALLEY SOUTH OF ITHACA, N. Y. (PHOTOGRAPH BY C. S. DOWNES.)

deposited that the moraine forms a very striking feature of the landscape. This is particularly true of many parts of the so-called terminal moraine of the Second Glacial Epoch.* Among some of the moraines of recession to the north of this, as well as in the

* Chamberlin, 3rd Ann. Rept. U. S. Geol. Survey, 1883, 291.

earlier Pennsylvania moraine to the south of it, the morainic topography is also very strongly developed.

The terminal moraine is essentially complex, and this applies both to form and structure. In form, or topographic detail, it is typically a system of hummocky knolls, with intermediate valleys, often saucer and kettle shaped, forming distinct, closed basins. The hummocks may reach to the dignity of good-sized hills, perhaps 200 or 300 feet high, though commonly not more than half this. Their form is often quite circular or sometimes elliptical, and again ridge-like. The hummocky hills are put together in such a confused manner that there seems to be no order whatsoever, the form being, on a much larger scale, somewhat the same as that produced when many loads of sand are dumped near

FIG. 14.—LAKES IN KETTLE HOLES IN MORAINE OF COLORADO ROCKIES (PHOTOGRAPH BY JACKSON, DENVER, COLORADO).

together without any attempt at order. Some of the hummocks are steep, others gently sloping, some symmetrical, and others distinctly unsymmetrical. I know of no type of topography which simulates that of the moraine with the exception of the wind-blown sand deposits in a sand dune region. In such places, judging from the form alone, one might often imagine himself upon a moraine.

The moraine is not a distinct ridge, but a range of low hills and valleys, with a breadth from north to south of rarely more than two or three miles, though sometimes, as in the southern end of the valleys of the larger Finger Lakes of New York, from ten to fifteen miles in a north-south direction. When seen in a near view, the moraine exhibits a striking topography; but when looked at as part

of a general hilly region, its importance becomes entirely masked,* because of the lowness of the hummocks. Indeed, many moraines in hilly districts have not yet been detected because of this very fact.

Next of importance to the hummocks are the valleys, which are often true basins called *kettle holes*. In places these are so prominent that the moraine has been called a kettle moraine. † In these basins there is often no water, because the bottom is too porous and the water supply slight, coming merely from the rim of the tiny basin; but where the drainage area is larger, or the bed more impervious, the kettles are often transformed to ponds or swamps. Indeed, in some places there are so many that the moraine is literally dotted with tiny morainic ponds (Fig. 15). The depth of

FIG. 15.—A PART OF THE NEW JERSEY MORAINE SHOWING (BY SHADING) NUMEROUS KETTLE PONDS (SALISBURY).

these kettles varies greatly, some mentioned by Koons being 50–90 feet deep.‡ These basin-like depressions are sometimes circular or elliptical or irregular, apparently being formed irregularly, as were the hills. Indeed, in many cases they are the spaces where morainic deposits were not made. The two types of form, valley and hill, cause a resemblance to the topography of sand dunes, in

* See Fig. 15 in Article III of this series, Bull. Am. Geog. Soc., XXX, 1898, where a very pronounced moraine, occupying nearly the entire valley south of Lake Cayuga, is masked by the general topographic features.

† Chamberlin, Trans. Wisconsin Acad. Sci., IV, 1876–77, 201.

‡ Koons, Am. Journ. Sci., 1884, Ser. III, XXVII, 260–264; Same, 1885, Ser. III, XXIX, 480–486.

which, between the more or less conical hills, there are numerous crater-shaped depressions or kettles.

Structure.—The internal structure of the moraine is also exceedingly complex. As in the case of the till sheet, it is sometimes almost free from boulders, sometimes exceedingly bouldery. In New York, the moraine is commonly rather free from large

FIG. 16.—THE BOULDERY CAPE ANN (MASS.) MORAINE (PHOTOGRAPH BY J. L. GARDNER 2ND).

stones, as is the till sheet also, the reason for this being that the rocks of the State are prevailingly soft and easily ground down. This is particularly true of central and western New York, where the scattered large boulders are mostly Canadian in origin; but in eastern New York there are places where boulders are more common, because of the greater hardness of the rock of the neighborhood and immediately to the north. In New England the prevailing condition of the till is bouldery, for the same reason.

When a morainic hummock is cut into and its internal structure revealed, it may be found to be till throughout, or it may be entirely made of gravel, or there may be a certain proportion of each of these. There is a complexity of structure which is most confusing; and one can see no law in the distribution of materials. Some moraines are prevailingly sand and gravel, others prevailingly till. One can rarely tell what will be found when a morainic hummock is cut through. There may be all till or no till, all stratified clay or

none of this, all sand and gravel or none; or some of each of these deposits may occur. Sometimes beds of sand or gravel are found

FIG. 17.—SECTION THROUGH A PART OF THE MORAINE IN CAYUGA VALLEY SOUTH OF ITHACA, SHOWING STRATIFIED DRIFT ON RIGHT AND UNSTRATIFIED TILL ON LEFT (PHOTOGRAPH BY C. S. DOWNES).

upon till. Again they occur beneath the till, or possibly sandwiched between two till beds.

Explanation of Morainic Irregularities.—There must be a cause for this variety of form and structure. In any specific case it would be exceedingly difficult to find the cause for each of the hills and kettles; and, indeed, even in general terms the explanation of these irregularities is not agreed upon. Professor Salisbury * considers moraines to be chiefly the result of accumulations of drift under the frontal edge of the ice, to which place it has been dragged and there left, because near the thinner ice edge it was impossible to carry the drift load further southward. To this cause is of course added certain supplies of material which was dumped from the ice-front as that melted, as well as some that was pushed or "shoved" up to the margin by ice advance; but these two last causes are believed to be subordinate. Other glacialists assign to the dumping process the chief importance, and still others believe that shoving has been of most importance. In fact, Professor Shaler † speaks of the "shoved moraine" as a synonym for a part of the terminal moraine.

* Ann. Rept. New Jersey Geol. Survey, 1891, 81.
† Ninth Ann. Rept. U. S. Geol. Survey, 546.

This is not the place for a discussion of the merits of this question. In fact, little good would come from such a discussion, for the matter resolves itself largely into a consideration of just how the individual conceives that the ice worked. It seems very probable that, at different times, or in different places, as the circumstances varied, either of these causes may have predominated. My own conception of how a moraine is built is that the dumping predominates in the main, with shoving as of secondary importance, while submarginal accumulation is more rarely of prime importance. This is based partly on my own conception of ice work, partly upon a somewhat wide-extended view of the terminal moraine of the eastern part of this country, and partly upon a study of the extensive moraine now forming in Greenland along a part of the margin of the great continental glacier. The statement that follows is therefore advanced purely as my own conception, and not necessarily that of others. It is recognized that very likely in the west, where the ice load was greater, submarginal accumulation may have been very much more important than it seems to have been in the east, and vastly more important than it *is* in Greenland.

The ice carried a greater amount of *débris* to some places than to others, partly because it actually had more material to carry, and partly because it was moving faster in some places than in others. This is one element of irregularity. Here and there this difference in supply may express itself in morainic accumulations *under* the margin of the ice; but wherever I have carefully studied the moraine there has been found no evidence that this was so. In Greenland, and evidently also in New York and New England, the chief moraine supply seems to have been from the ice front. This ice this season perhaps different from last, just as living glaciers change front, while holding a general position, shifted somewhat, being their front in different seasons. Hence material previously deposited at the glacier front may have been overridden, and perhaps shoved up into ridge-like hills; or, if the ice withdrew, new areas would be opened to the process of dumping.

All of this time the ice is moving up to the end, bearing its load, which, when the ice melts, slides down to the base in the form of pieces varying from bits of clay to large boulders, and more perhaps coming to some places than to others. This process may be actually seen in Greenland to-day. If the ice advances, overriding, or possibly even shoving some of the moraine in front of it, the deposits are heaped up even more irregularly than by the first dumping. That something of this sort has happened is indicated by the fact

that in the moraine the strata are often tilted and broken, showing that they have been subjected to some force.

Hills and valleys are formed as the ice front changes its line of dumping. This is the cause for the hummocky topography in the Greenland picture (Fig. 8), and seems perfectly competent to explain the similar irregularity in this country. In fact, until proof is brought to the contrary, this view seems to stand best supported by fact.

The irregularity of form described above, as well as the irregularity of texture, is increased greatly by the action of water from the ice. In some cases the moraine is being built upon a hillside sloping away from the ice, and then the water may remove much that the ice brings; but if the opposite is true, very little escapes, so that, with the same rate and amount of till supply, we may have great or small moraines built according to whether or not the water carried off much of the drift.

This cause for the irregularity applies equally in a small way. Here a stream was cutting a hummock away; there it was depositing a part of that which it had removed, perhaps in little marginal lakes extending along the ice front. Hence the conditions were exceedingly complex, so that, naturally, the results were complex both as to structure and form. This complexity of conditions exists along the Greenland ice margin at present and probably also existed in this country.

While advocating this view, it is not insisted that submarginal accumulation is impossible, nor are the three causes above mentioned *all* that were possible. The surface of the ice may have become covered with rock *débris*, as may be seen in the Malaspina Glacier of to-day; and this, through irregularity of melting of the ice which the *débris* covered, may have assumed distinctly morainic form and structure, and then, as the ice melted, have been dropped to the ground to add to the other accumulations. Again, *débris* washed from the land to the ice margin, or even out upon it, may have helped make the moraine. Such an origin is indicated for a part of the moraine in the Lake Cayuga valley, and apparently accounts, in part, for its remarkable development in that valley, while elsewhere along the same morainic line, the topography is generally especially marked only in the valleys, and is sometimes almost indistinguishable.

The Extent of the Moraine in New York.—No attempt will be made here to tell in detail about the distribution of the New York moraines. What little is known is mostly told upon the accom-

panying maps (Figs. 10 and 11); but it is to be understood that the Chamberlin map is an approximate and generalized expression of morainic districts and will not bear the test of local criticism. Numerous moraines are not placed upon it, and those that are, are not always correctly placed. It was based upon a preliminary reconnaissance, and, unfortunately, nothing of a more accurate nature has since been done in the greater part of the State.

A few words of a general kind may accompany this map. It will be noticed that the moraine enters New York from the southwest, just to the southwest of the lower end of Chautauqua Lake. There at Jamestown it is remarkably well developed, and, from this point, the lines of moraine diverge, one passing northeastward toward the west boundary of the Genesee Valley, the other passing very near Salamanca southeastward into Pennsylvania, and thence on to New Jersey.* With the interpretation of Lewis and Wright, that the southernmost moraine is in reality the outermost moraine of the last glacial advance, I am in full agreement. The facts presented by these writers have never been satisfactorily disproved, and one who has gone over the region can hardly fail to accept their conclusions. Therefore, notwithstanding the difference of opinion expressed upon Chamberlin's map, I accept the interpretation of the Pennsylvania geologists.

According to this view the actual terminal moraine entered New York State, aside from the Long Island region, in only one place, which is the place where the ice front stood farthest north in eastern United States. The reason why the glacier did not reach farther south in western New York is partly the effect of the very high plateau region of rugged topography which exists in northern Pennsylvania and southwestern New York. This actual terminal moraine of Lewis and Wright is well developed in central New Jersey, and again enters the State of New York in New York Bay, where it crosses to Long Island. The sandy and hummocky hills of this island are in large part due to the remarkable development of the terminal moraine,† which may be traced still further east-

* This moraine is the one described by Lewis and Wright. See reference, page 193.

† Bryson, Geol. Mag. X, 1883, 169–171; Amer. Geol. III, 1889, 214; Same, 1893, XII, 127, 402; Same, 1894, XIII, 390; Same, 1895, XV, 188; Same, 1895, XVI, 228; Dana, Amer. Journ. Sci., 1890, XL, Ser. III, 425–437; Same, 1891, Ser. III, XLI, 161; Hollick, Trans. N. Y. Acad. Sci., XII, 1893, 189–202, 222–237; Same, 1895, XIII, 122–130; Same, 1894, XIV, 8–20; Same XV, 1895, 3–10; Same, XVI, 1896, 9–18; Lewis, Am. Journ. Sci., 1877, XIII, Ser. III, 142–146; Mather, N. Y. Geol. Survey, 1st Dist., 1843, 271; Merrill, Ann. N. Y. Acad. Sci., 1883–5, III, 341–364; Upham, Am. Journ. Sci., 1879, XVIII, Ser. III, 81–92, 197–209.

ward upon Block Island, the Elizabeth Islands, Martha's Vineyard and Nantucket. Although probable, it is by no means certain that the Long Island moraine is the actual terminal moraine, for it is still possible that the ice front to the south of New England was at one time in the sea to the southward of Long Island. In that case the Long Island moraine may correspond with one of the later halts, possibly with the well developed one in west central New York. Much careful work is necessary before the exact correlation of the several moraines is possible.

North of this extreme terminal moraine are numerous morainic patches, and somewhat indistinct lines of morainic topography, many of which are not yet located and correlated. There is also some moraine in the valley of the Chemung and Susquehanna Rivers, as well as in some of their tributaries, indicating a series of brief halts of the ice. Still further north, in the Genesee Valley, and along the headwater region of the Finger Lakes, and thence northeastward to the Mohawk, there is much moraine, indicating a prolonged halt of the ice, with the front by no means uniform in position. The history marked by this development of moraine has never been worked out, though it is not so simple as might be supposed from the map (Fig. 10). There were numerous minor halts and fluctuations of position in the general stand in this vicinity. This moraine is strongly developed, but from the valleys alone one would get an erroneous notion of its importance. There are places on the hills where this moraine, strongly developed in the valleys, is traced with difficulty. The detailed work of Leverett,* indicated by the map (Fig. 11), gives some idea of the complexity of the ice withdrawal from western New York.

North of this well developed morainic band there are others, the best developed one being north of the Finger Lakes, and not shown by the Chamberlin map. In the Adirondack region there are other moraines of recession.† Concerning the moraines of the Adirondacks, the Catskills, and other sections of eastern New York, practically nothing is known.‡ There certainly are moraines in this region, as there are in New England; and in all probability the

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* Am. Journ. Sci., Ser. III, L. 1895, 1–20.

† For an interpretation of the withdrawal of the ice front from North America, see Upham, Am. Journ. Sci., 1895, XLIX, Ser. III, 1–18; Bull. Geol. Soc. America, VII, 1896, 23; Chalmers, Amer. Journ. Sci., 1895, XLIX, Ser. III, 273–275.

‡ Some notes on Glacial Geology of New York will be found in the following: Dana, Am. Journ. Sci., 1863, XXXV, 2d Ser., 243–9; Stevens, Amer. Journ. Sci., 3d Ser., 1872, IV, 88–90; Julien, Trans. N. Y. Acad. Sci., III, 1883, 22–30; Brigham, Amer. Journ. Sci. 1895, Ser. III, XLIX, 213–228.

recession of the ice from this section of the State was much more complex than in the central and western portions; for, in addition to the moraines made by the great ice sheet, very much influenced by the rugged topography, and hence scattered and difficult to trace, there were no doubt local glaciers in the mountain valleys, as there are now in Greenland, and as there were at the close of the Glacial Period in New Hampshire and Maine. The mapping and correlation of these moraines is one of the important problems on the geology of New York and one that will do much to tell what the ice really did. Until such work has been done in New England and New York we will have but a meagre knowledge of the great American ice sheet.

OVERWASH PLAINS AND VALLEY TRAINS.—These have already been mentioned in the third article of this series* and can therefore be briefly dismissed here. Where the glacier front stood for a long enough time to build morainic hills, the floods of water, being commonly overburdened with sediment, built up deposits of stratified gravel on the southern side of the moraine. Where the topography was not rugged, numerous ice-derived streams built sloping plains resembling low alluvial fans. These are well seen on Long Island and Martha's Vineyard, and to those of the latter place Professor Shaler has given the very descriptive name of frontal aprons.† The plains on the southern slope of Long Island are of this origin, and they are often crossed by the channels of the streams that built them, though now at times no water flows in them.‡ Overwash plains, as these are also called, are not confined to this section, but in less perfect development are found every here and there on the southern side of the New York moraine, particularly in the south sloping valleys. The best instance with which I am familiar outside of Long Island is that upon which the town of Horseheads, north of Elmira, is situated.§

These plains often merge into valley trains of stratified drift. Practically all the south-sloping valleys of western New York have been embarrassed by these deposits,‖ which are sometimes very deep. The Susquehanna and its tributaries, even beyond the boundary of New York, contain deposits of this origin, so that now

* Bull. Am. Geog. Soc., XXX, 1898, 42–44. See Salisbury, 1892 Report, New Jersey Geol. Survey, 96–125.

† Shaler, 9th Ann. Rept. U. S. Geol. Survey, 1889, 548.

‡ See references above to the Long Island moraine.

§ Fairchild, Bull. Geol. Soc. Amer., VI, 1895, 367.

‖ Brigham, Bull. Geol. Soc. Amer., VIII, 1897, 17–30.

this stream, as in the case of many others, is flowing high above the old rock bottom of the preglacial valley. By this means much of the glacial drift was removed well beyond the ice margin, and not a little of it reached to the sea. The stream valleys sloping away from the ice all show some effects of this flooding with sediment-laden glacial water. These deposits grow finer and finer as we proceed down stream, being coarse gravel near the moraines and oftentimes fine clay near the sea.

The surface of overwash plains, valley trains, moraines and sandplains (described just below) is often pitted with little kettle-shaped depressions.* These kettles are sometimes caused by irregularities of deposit, either through differences in supply of material, or in direction or form of currents which were swirling about, forming eddies here and there. In other cases, and perhaps the majority, the kettle has resulted from failure to deposit material, because that particular part of the surface was occupied by an ice fragment or stranded iceberg, which had stratified drift deposited all around it and finally over it, and then, melting away, left the material to settle down, forming a kettle hole. In the marginal lakes on the coast of Greenland instances of this may be seen; and it is probable that while the American ice sheet was melting away, the conditions favoring this mode of formation of basins were in operation.

Lake Deposits.—As will be shown in a later article under the discussion of the Great Lakes, during the retreat of the glacier many lakes were made in regions where now they are impossible. Then there were ice dams where now there is no barrier to the free northward flow of the rivers. As the ice front withdrew, passing north of the Allegany and Susquehanna-St. Lawrence divide, each of the valleys that sloped northward was dammed by the glacier, forming lakes in their southern ends, the area of which grew as the glacier front stood farther and farther north, until, finally, the withdrawal was sufficient to admit of a northern outflow, when the lake level fell. This distinct lake history by itself has been interesting, and is told by the deposits made during the time that the waters were thus ponded.†

Along these lake shores, beaches and bars were in some cases built, while deltas were very commonly formed at the mouths of

* See references to Koons, p. 198, and Woodworth, Amer. Geol., 1893, XII, 279.

† Fairchild, Bull. Geol. Soc. Am., VI, 1895, 353–374; Lincoln, New York State Museum Report, XLVIII, Part 2, 1894, 74–77.

the tributary streams. These, however, are not strictly glacial deposits, though in cause intimately related to the glacier. But in the lakes, deposits of stratified drift were also made from material derived directly from the ice. As the streams emerged from the glacier into these lakes, they poured their volumes of sediment into the quiet lake waters, where it settled, the coarsest near the glacier, the finer farther away, forming there a layer of lake clay. This is especially well developed along the southern shores of Lakes Erie and Ontario, though not absent from the numerous smaller valleys of the Finger Lake region. To these were added deposits dropped from the glacier itself, and still others floated away into the lake, buoyed up by the tiny icebergs that must have floated away from the ice front.

These deposits have not notably modified the surface of New York, though they have added somewhat to the glacial modifications of the details of topography. Near the ice margin, at its various stands, deposits must have been rather extensively made near the mouths of the sub-glacial rivers. No doubt such deposits are common in portions of the State, though they have not been described from there. In New England they are found quite commonly, especially near the coast, where they are called sandplains.* These are really deltas in a body of water now absent. The material was supplied from the melting of the ice, and the form of the deposit is that of a true delta, flat-topped, with steep front, and traversed by stream channels, and sometimes pitted on the surface by kettles, probably formed by the same means as those mentioned above (page 206).† Future study will no doubt discover sandplains in New York.‡

KAMES.—Throughout New York, commonly in association with the moraines, but often isolated, are single hills, or groups of hummocky hills, of stratified drift called kames.§ In topographic form they resemble moraines and are often a part of these deposits; but elsewhere they seem to bear no relation to morainic bands. Single

* There is reason for believing that some of the New England sandplains are really deltas formed in the sea when the land was somewhat lower than at present, as it was during the close of the Glacial Period. The evidence of this will be published in a forthcoming number of the American Geologist.

† For a discussion of sandplains see Davis, Bull. Geol. Soc. Am., I, 1890, 195–202; Davis, Proc. Boston Soc. Nat. Hist., 1892, XXV, 477–499; Gulliver, Journ. Geol., 1893, I, 803–812; Salisbury, Ann. Rep. New Jersey Geol. Survey, 1892, 99–102.

‡ Tarr, Bull. Am. Geog. Soc. XXX, 1898, 45.

§ Salisbury, Ann. Rep. N. J. Geol. Survey, 1891, 92–95; Same, 1892, 84–95.

hummocks may be found upon hillsides or even hilltops. They sometimes show a confused stratification with the layers dipping in various directions, and exceedingly variable in texture. Moreover, the layers are sometimes broken, showing disturbance subsequent to deposit. In different places their origin is apparently quite different. Glacial water has evidently made them ; but there are various ways in which this water may construct hills of stratified drift. Deposits in caverns under the ice, hills made by cascades carrying much sediment down the ice front or through crevasses into the ice, and deposits in tiny lakes upon the surface of the glacier, and later lowered to the ground when the ice melted, are some of the more common ways in which kames may have been made. By this action hills several scores of feet in height have been constructed.

Naturally the conditions favoring such deposits will exist only near or at the ice margin; but as this front was in all parts of the State at different times, kames may be found in any part of New York, and indeed they do occur all over the State, sometimes rising in what appear to be the most unnatural positions. Where the ice stood longest they would be most abundant; and hence they are most common in association with the moraines. Slight forward movements of the ice would break and disturb the layers as we find them. Few specific cases of kames have been described in New York,* but they are known here and have also been described from various parts of the country.†

Eskers or Serpent Kames (Osars).—Ridges of gravel, bearing a close resemblance to embankments, are frequently found within the glacial area. In these the material is usually coarse. Sometimes they are made of good-sized and well-rounded pebbles, oftentimes several pounds in weight. Sometimes, however, eskers are made almost entirely of sand. The stratification, while often noticeable, is usually somewhat confused, and the ridge may be coarse in one place and much finer in another.

In the form of eskers there is much variation. Typically they are distinct, narrow-topped ridges, extending in a more or less irregular or serpentine course. Some are mere low banks; others

* See particularly Fairchild, Am. Geol. 1895, XVI, 39–51 ; Same, Journ. Geol. IV, 1896, 129–159; Brigham, Bull. Geol. Soc. America, VIII, 1897, 17–30 ; Lincoln, New York State Museum Report, XLVIII, Part 2, 1894, 72–74.

† For instance, see Upham, Hitchcock's Geol. of New Hampshire, Vol. III, 1878, 12–176; Lewis, Second Geol. Survey Pa. Rept. Z, 1884, 35–36; 61–65; 78–81; 100–111, etc.; Chamberlin, Journ. of Geol. 1893, 1, 255–267.

have a height of several scores of feet. In some cases the crest of the ridge is level; but more commonly it undulates somewhat and has a gradual slope in one direction, normally sloping downward in the direction of ice movement as revealed by the striæ upon the bed rock. Variations from this normal form are common. At times the ridge is interrupted, or it may end abruptly, or even very gradually, often terminating in a broad, sandy area. Some eskers

FIG. 18.—SIDE VIEW OF ESKER, AUBURNDALE, MASS. (PHOTOGRAPH BY JOHN RITCHIE, JR.).

end in sandplains.* These ridges may even end in a tiny valley cut in the till.

As for location, they may be found anywhere within the glacial belt, though they are more common near the moraines. They are very abundant in eastern New England, and have been well described for the Boston region.† Among the mountains of Maine ‡ and New Hampshire § they are common. The term esker is an Irish name,‖ and these peculiar ridges are common in Ireland, as

* See Davis, Bull. Geol. Soc. Am. I, 1890, 195–202; Davis, Proc. Boston Soc. Nat. Hist., 1892, XXV, 477–499; and Gulliver, Journ. Geol. I, 1893, 803–812.

† Bouvé, Proc. Boston Soc. Nat. Hist., XXV, 1891–92, 173–182.

‡ Jackson, Geol. of Maine, 1st Rept., 1837, 64; Stone, Proc. Amer. Assoc. Adv. Sci., 1880, XXIX, 510–19.

§ Upham, Hitchcock's Geol. of New Hampshire, Vol. III, 1878, 12–176. For New Jersey eskers, see Salisbury 1892 Report New Jersey Geol. Survey, 79–83.

‖ Young, Report Brit. Assoc., 1852, XXII, Part 2, 63–64; Kinahan, Amer. Journ. Sci., 1887, Ser. III, XXXIII, 276–278.

elsewhere in the British Isles * and northwestern Europe. In Scandinavia they are called äsar (anglicized osars). Little work has been done upon the eskers of New York, though they occur in association with the moraine. † Instances of eskers may be seen near Freeville, New York, and along the Lehigh Valley Railway west of Geneva. In all probability they are common, particularly in the more hilly sections, such as the Adirondacks.

As for the details of location, eskers are very commonly found in valleys, but by no means confined to them. They have been found upon hillsides and are known to cross valleys, extending

FIG. 19.—CREST OF ESKER, AUBURNDALE, MASS. (PHOTOGRAPH BY JOHN RITCHIE, JR.).

down one side and up the other. ‡ Such conditions are exceptional, and the type location may be said to be the valley, or else the immediate neighborhood of a moraine. Here they may be but a few score of yards long or may extend for miles. Some of the eskers of Maine are exceedingly long and well developed. When typically developed they have a remarkably artificial appearance, sometimes closely resembling an abandoned railway embankment. They have in some cases been explored in the belief that they were Indian mounds.

* Howe, Report Brit. Assoc., 1861, XXXI, Part 2, 115–6.

† Upham, Proc. Rochester Acad. Sci., II, 1893, 181–200; Fairchild, Journ. Geol., IV, 1896, 129–159.

‡ Shaler, Ninth Ann. Rept. U. S. Geol. Survey, 549.

Their form and characteristics point plainly to stream origin and to the conclusion that they are really the beds of glacial streams. There has been some question whether these glacial stream beds were formed under the ice (subglacial) or in the ice (englacial), or upon the ice (superglacial), and this question is still an open one.* The facts seen in living glaciers †, and those discovered by the study of existing esker deposits, point to a subglacial river origin as by far the most probable ‡, although other facts brought forward seem to show that there are some eskers which have been formed by superglacial or englacial streams. §

Near the ice front streams were flowing in each of these positions, but by far the greater amount of drainage near the ice terminus must have been subglacial. In either case the running water was supplied with much sediment which was being dragged along the stream bed. Wherever more was given than the stream could remove, deposits were necessarily made in the stream bed. Since the ice contained many pebbles and boulders, as well as finer clay, it would not uncommonly happen that the stream could not remove as much sediment as was given to it. Then, at the bottom of the ice cañon, an embankment of gravel would be built, held in by ice walls, and resting either upon the ice (in englacial or superglacial valleys), or on the ground if subglacial. When the ice withdrew, the stream deposits would settle, the sides taking the slope of gravel at rest ‖, but retaining the average slope of the stream bed (if this were on the ground) and its meandering direction. Therefore the esker represents a fossil glacial stream bed, whether subglacial or superglacial or englacial.

The confused stratification is due to the irregularity of deposit, later settling, and possibly to disturbances caused by ice movement. The interruption of form may be due to ice movement or to failure

* Davis, Proc. Boston Soc. Nat. Hist., 1890–92, XXV, 477–499; Chamberlin, Journ. of Geol., 1893, 1, 255–267; Upham, Bull. Geol. Soc. Am., V, 1894, 71–84; Amer. Geol., 1894, XIV, 403–405; Winchell, Am. Journ. Sci., 1881, XXI, 358–60; Sollas, Report British Assoc., 1893, 63, 777; Russell, Am. Journ. Sci., 1892, Ser. III, XLIII, 178–182; Same, Thirteenth Ann. Rept. U. S. Geol. Survey, Part II, 81–82; Reid, 16th Rept., Part I, U. S. Geol. Survey, 442.

† Russell, Amer. Journ. Sci., 1892, Ser. III, XLIII, 178–182; Same, Thirteenth Ann. Rept. U. S. Geol. Survey, Part II, 81–82; Reid, 16th Rep., Part I, U. S. Geol. Survey, 442.

‡ Davis, Proc. Boston Soc. Nat. Hist., 1890–92, XXV, 477–499; Chamberlin, Journ. Geol., 1893, 1, 255–267.

§ Winchell, Amer. Journ. Sci., 1881, XXI, 358–60; Upham, Bull. Geol. Soc. Am., V, 1894, 71–84; Am. Geol., 1894, XIV, 403–405.

‖ Woodworth, Proc. Boston Soc. Nat. Hist., XXVI, 1895, 197–220.

to deposit in particular places; and the broadening out in places, from the ridge slope to the low sandy areas, may either represent the terminus of the esker stream, at the glacier margin, or some broad part of its ice-walled valley. The location of eskers upon hillsides may be easily accounted for. If formed on or in the ice, the valley location is essentially accidental; and when the ice disappears the eskers may settle upon the hillsides, as well as in a valley. If, on the other hand, as seems much more commonly, if not almost universally, the case, the esker stream was subglacial, the water building the esker was flowing in an ice channel under considerable pressure, so that it might even flow up hill, if the hill were not higher than the pressure head, for the same reason that water flows through the pipes to the second story of our houses. In this case the esker location would generally be along valleys, and this is the case.

THE TILL SHEET.—The material that was on, in, or under the ice (superglacial, englacial and subglacial till) at the time it melted away from any given place, was left upon the surface of the country

FIG. 20.—SECTION IN VERY BOULDERY MORAINIC TILL, CAPE ANN, MASS. (PHOTOGRAPH BY J. L. GARDNER 2ND).

as a till sheet, that part removed by water being of course excepted. This till sheet, which covers the greater part of New York, and particularly the hillsides and tops, varies greatly in character from place to place. Typically and prevailingly it is a *boulder clay*, which, as the name suggests, is essentially a boulder-bearing clay.

The percentage of boulders varies from nearly boulder free to a class of till in which more than one-half the mass is made of boulders. The clay is a rock flour made by the grinding of the rocks as they are dragged along by the ice; and this abrasion is further indicated by the fact that many of the boulders and pebbles are grooved and polished.

The color of the till sheet varies greatly, depending in large measure upon the color of the rocks over which it passed just before it was deposited. This indicates a rather local origin for much of the till; and this is borne out by the fact that among the boulders are found many of local origin. Still, in a region where the

FIG. 21.—BOULDER-STREWN SURFACE OF MORAINIC TILL, CAPE ANN, MASS. (PHOTOGRAPH BY J. L. GARDNER 2ND).

rocks are soft, as they are in the shale country of central New York, these fragments are worn so rapidly that they may be less numerous than the Canadian boulders and pebbles which, though brought from afar, being harder, have been better able to stand the long journey than the shale fragments were the much shorter one. The farmers have practically asserted this fact when they have called these foreign boulders, resting in the midst of soft shale strata, by the very descriptive name of "hardheads." In the region from which the hard heads have come boulders may be so common that, as in parts of New England, the soil is almost incapable of cultivation.

While the color of the drift is variable, its general color, when fresh and unoxidized, is blue, grading to a yellow near the surface where stained with the limonitic iron stain formed during oxidation of iron-bearing minerals. The blue color is due to the finely comminuted and undecayed dark particles, and may be present even when the till has been derived from light colored gneissic and granitic rocks.

Although typically a clay, the till is sometimes sandy, though not commonly. When very clayey it is often so compact that it is difficult to dig through it with a spade. This has been given the name of "hard pan," and it owes its compactness not merely to the fineness of the clay, but also, at times, to the fact that it has been pressed into a compact condition by the weight of the ice which once rested upon it.

The mode of origin of this till sheet was, first, the removal of loose fragments from the surface, then, with the aid of these, the grinding off of others, accompanied by the grinding of the various particles into finer bits. In position, while some of the fragments may have been upon the ice top, and some within the ice, the greater part was dragged along, either just beneath the ice, or frozen in the lower layers of the glacier. In Greenland the latter is the common mode of transportation of the *débris* load. This glacier has a smaller burden of rock fragments than the American glacier, and the till sheet which it is depositing is, therefore, much less developed. There is good reason for believing that some of the American till was dragged along beneath the ice, so that here, as in some other respects, the Greenland glacier of to-day is not a fair guide for conditions prevailing in America during the Glacial Period.

This rock load, wherever carried, was left upon the surface of the land with the retreat of the glacier. In examining the surface of a large area, like that of New York, we find that this till sheet varies greatly in depth. There are places where there is almost none except in the little depressions, and this is particularly the case among the high gneissic peaks of New England and the Adirondacks. This means either that none was deposited or else that it has been removed; and sometimes one explanation is correct, sometimes the other. This is the prevailing condition in Greenland, where the slopes are great and the original till deposit slight. Frequently the till is but a few inches or feet in depth, and then the rock is reached in ordinary trenches. This condition is most common upon hilltops or upon those hillsides where we may believe the

ice movement to have been relatively rapid. In such places little was left, because little was held under the ice, the movement being rapid enough to prevent such accumulations, somewhat as a river with rapid flow, during the time of flood, can clear its bed of the gravel bars that were accumulated at some time of less rapid movement.

The thickness of the till sheet varies progressively also over wide areas. As a general statement, subject to many modifications locally, the till sheet of New England and eastern New York is thinner than that of western New York, and this is thinner than that of the Central States, where it is sometimes two or three hundred feet deep.* This general change in thickness is parallel with a change in topography from mountain to hill and then to plain. Over the latter the ice slope was slight and the current probably less rapid than in the more irregular regions of the east. The variation is also parallel with a change in rock texture. In the east the strata are prevailingly hard; in the west relatively soft, although of course to this there are certain local exceptions. From a region of soft rock more drift is supplied than from one of hard, and this is one of the reasons why the Greenland glacier has so little drift. It follows from this that in the central west the ice wrested more drift and was less able to remove even a small supply than in the east. Hence beneath the ice much till was accumulated in the western section, while in the east the opposite holds true, as a general statement.

As has been said, this general statement needs modification locally. Among the Adirondacks, and in New England, the ice currents were often retarded by some rocky hill, around which the ice must flow. Upon the southern or lee side of such a hill the conditions favored deposits beneath the ice; and consequently, while the north side of such hills is nearly bare of drift, the southern side often has a deep till soil. Here very often the rocky hill has been prolonged southward as a drift hill formed by the deposit of a tail of drift upon which, very likely, a farm is situated, while all around is untillable and hence wooded land. This drift material, combed down from the hilltop and sides, and accumulated in the slack ice current on the lee side of the hill, forms a distinct element in the landscape of many of the hilly sections.

Still another case may be introduced. Rather narrow east-west valleys extended across the course of the south-moving glacier, as

* Calvin, Amer. Geol., I, 1888, 28–31; Leverett, Am. Geol., IV, 1889, 6–21; Claypole, Bull. Geol. Soc. Am., III, 1892, 150–151.

was very commonly the case in central and western New York. Down into these the ice currents could not move as readily as along the hilltops, and hence here too, material from the hilltops was combed off and dragged beneath the ice into the valleys. The result

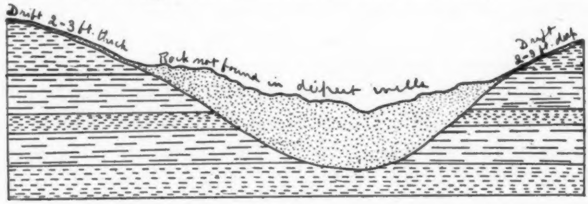

FIG. 22.—SECTION TO SHOW DEEP DRIFT FILLING IN NARROW EAST-WEST VALLEYS NEAR ITHACA, N. Y.

has been that in such valleys the till is deep, gradually becoming thinner upon the hillsides. The diagram is based upon these conditions as exhibited in scores of places near Ithaca, N. Y. In these cases the valley has been made more shallow and its bottom broader than before the ice came, and by these causes the topography of the New York-Pennsylvania plateau has been greatly modified.

Not only have valleys been shallowed, but in some cases they have been entirely obliterated. Near Ithaca there are numerous

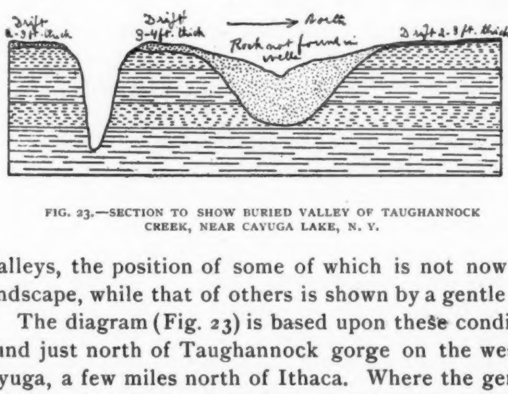

FIG. 23.—SECTION TO SHOW BURIED VALLEY OF TAUGHANNOCK CREEK, NEAR CAYUGA LAKE, N. Y.

buried valleys, the position of some of which is not now indicated in the landscape, while that of others is shown by a gentle sag in the hillside. The diagram (Fig. 23) is based upon these conditions now to be found just north of Taughannock gorge on the west side of Lake Cayuga, a few miles north of Ithaca. Where the general drift sheet is thick, and the original topography less irregular, as in the central west (and apparently also in the Ontario region*), the preglacial drainage lines are almost entirely obliterated. By boring for oil, some of them have been discovered, where, without the

* See article III of this series, Bull. Amer. Geog. Soc. XXX, 1898, 52–54.

facts thus obtained, the extent of the preglacial land irregularities would not be known.*

There are several other causes for irregularity in the depth of the till sheet, the exact causes of which are not apparent. Sometimes the till is locally thicker than elsewhere without any evident relationship to the topography. Its surface rises and falls in gentle swells, or rises into hummocks or ridges. This irregularity has led Professor Chamberlin † to suggest certain names, such as mammillary hills, till tumuli, etc., to designate the several types. Nothing more can now be said about the cause for these than that they must be related either to some unusual variations in supply, or in ice currents, or be due to the influence of minor topographic features, the nature and extent of which is not always easy to determine. They fall among the category of the altogether too numerous instances of unexplained glacial phenomena. We need specific studies of these forms and the collection of facts concerning them.

DRUMLINS.—Among the irregularities of the till none form such a striking element of the topography as those till hills which are classed as drumlins. These were first fully described in Ireland, whence their name.‡ In this country they occur in eastern Massachusetts§ and southern Connecticut, as well as in other parts of New England.‖ They occur also in Wisconsin.** Generally they are found in clusters, though many isolated drumlins are known. These peculiar hills are said to occur in the Adirondacks and in eastern New York,†† though I find no description of these localities; but one of the most notable accumulations of drumlins in the world exists

* Newberry, Geol. Survey Ohio, 1869, 24–33; Andrews, 60–64; Newberry, Geol. Survey Ohio, Vol. I, 1873, 85–88; 174–184; Orton, 425–434; 438–449; 455–462; Gilbert, 537–556, and other parts of Report.

† Chamberlin, Third Annual Rept. U. S. Geol. Survey, 1883, 296–309; Compte Rendu, Congrès Géol. Inter. Washington, 1891, 176–192; Journ. of Geol. 1894, II, 517–538.

‡ Kinahan and Close. General Glaciation of Iar-Connaught, Dublin, 1872.

§ Shaler, Proc. Boston Soc. Nat. Hist., XIII, 1869–1871, 196–204; Upham, Proc. Boston Soc. Nat. Hist., XX, 1878–80, 220–234; Marbut & Woodworth, 17th Annual Rept. U. S. Geol. Survey, Part I, 995; Davis, Science, IV, 1884, 418–20; Amer. Journ. Sci., 1884, XXVIII, Ser. III, 407–16.

‖ Hitchcock, Proc. Boston Soc. Nat. Hist., 1876–78, XIX, 63–67; Upham, Hitchcock's Geol. of New Hamp., Vol. III, 1878, 287–309; Hitchcock, 309; Upham, Proc. Amer. Assoc. Adv. Sci., 1879, XXVIII, 309.

** Chamberlin, Journ. Geol., 1893, I, 255–267; Upham, Am. Geol. 1894, XIV, 69–83.

†† Upham, Bull. Geol. Soc. Am., III, 1892, 142.

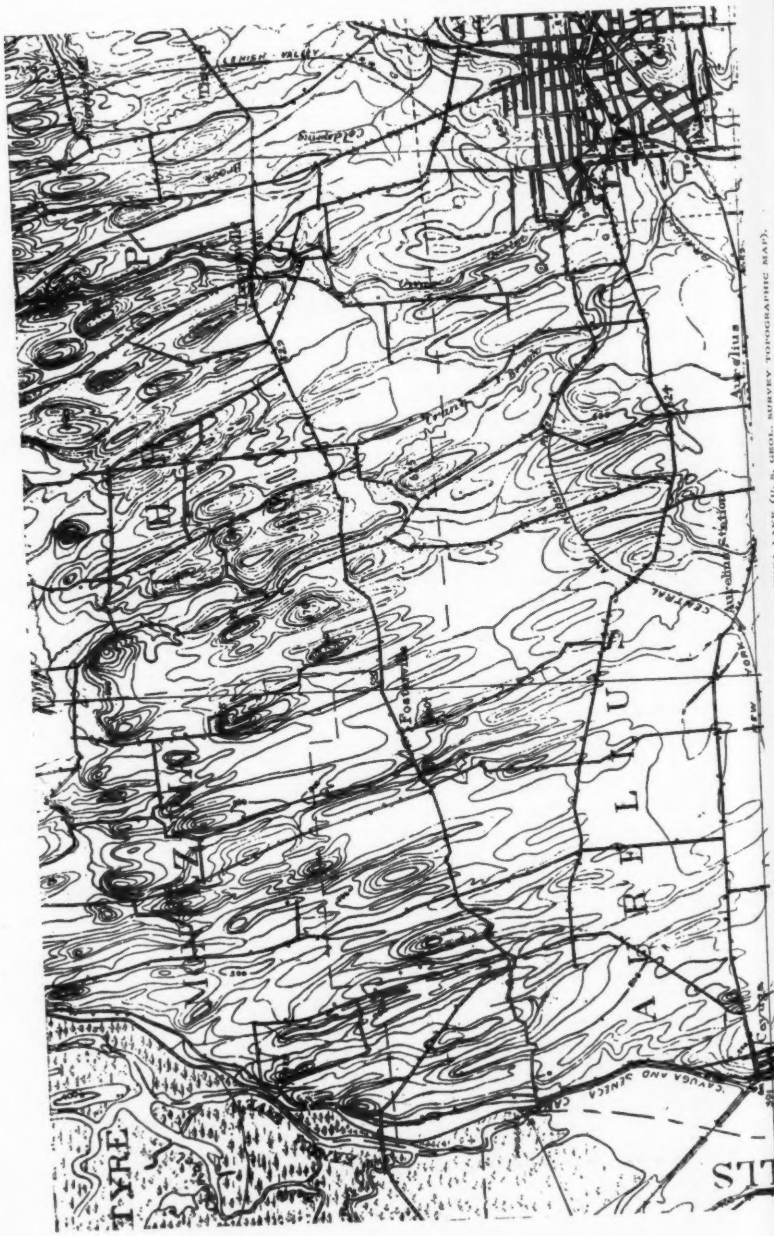

FIG. 34.—A PART OF THE DRUMLIN REGION NORTH OF CAYUGA LAKE (U. S. GEOL. SURVEY TOPOGRAPHIC MAP).

in the region between Syracuse and Rochester along the line of the New York Central Railway. As in the case of most of the other glacial features of New York, we have no adequate description of these interesting hills.*

The New England drumlin is typically a beautiful and symmetrical hill, elongated in form, having a shape resembling that of an egg when half submerged in water, with the long axis parallel to

FIG. 25.—A TYPICAL NEW ENGLAND DRUMLIN NEAR IPSWICH, MASS. (PHOTOGRAPH BY J. L. GARDNER 2ND).

the water surface. The length may be a half to three-quarters of a mile, the width a fifth to a half a mile at the base, and the height perhaps one to two hundred feet. There are longer and shorter, broader and narrower, and higher and lower forms than this type. The curves are wonderfully regular, but commonly the northern end is steeper than the southern. This type is well illustrated by scores of hills in Boston harbor, and near Boston, especially north of that city as far as the Ipswich coast. The long axis of the New England drumlin is parallel to the direction of ice movement, and the material of which they are composed is mainly till, though very often they contain stratified drift.† The Wisconsin drumlin is

* Hall, Geol. of N. Y. 4th Dist. 1843, 341 ; Johnson, Ann. N. Y. Acad. Sci., II, 1882, 249–66; Abstract in Trans. N. Y. Acad. Sci., 1882, I, 77–80; Davis, Science, IV, 1884, 419 ; Lincoln ; Am. Journ. Sci., XLIV, 1892, 290–301 ; New York State Museum Report, XLVIII, Part 2, 1894, 69–71.

† Upham, Proc. Bost. Soc. Nat. Hist., XX, 1878–80, 220–234 ; Same, XXIV, 1888–89, 127–141 ; Same, XXIV, 1888–89, 228–242 ; Same, Amer. Journ. Sci., 1889, Ser. III, XXXVII, 359–372 ; Crosby & Ballard, Amer. Journ. Sci., 1894, Ser. III, XLVIII, 486–496 ; Marbut and Woodworth, 17th Annual Rept. U. S. Geol. Survey, Part I, 995 ; Upham, Amer. Geol. XX, 1897, 383–387.

often much shorter and less symmetrical,* the Irish type much longer.†

The drumlins of central New York approach the Irish type much more closely than those of New England. Their form varies from the southern margin to the northern. In the latter part of the belt, they are often very much like the Boston type, though considerably less symmetrical and with steep northern faces. Near the southern margin of the drumlin belt they are exceedingly long and low ridges, the length being sometimes more than two miles and the height very often less than one hundred feet at the highest point, which is close to the northern end. Some ridges, perhaps three-quarters of

FIG. 26.—LOW DRUMLIN RIDGE NEAR SOUTHERN MARGIN OF NEW YORK DRUMLIN AREA, JUST EAST OF CAYUGA (PHOTOGRAPH BY W. B. GREENLEE).

a mile long, are not more than forty feet high at the highest point. In fact, these low drumlins simulate the esker in form. Even many of the higher drumlins of this section change to low and long ridges in the southern part, and their exact southern terminus is often incapable of location, for it flattens out into the undulating till sheet very gradually. Sometimes this terminus is in the irregular morainic topography. In all cases the northern end is well defined and relatively steep.

While some of the drumlins are long and low, with an even-topped crest line, sloping gradually southward, others have an undulating crest, giving a very ragged sky line. Whether this is a part of the original form of the drumlin, or has been caused by later

* Chamberlin, Geol. Survey, Wisconsin, I, 1873–79, 283.

† Kinahan and Close, General Glaciation of Iar-Connaught, Dublin, 1872.

denudation has not been determined, though there are some reasons for supposing that the latter is true.

Between the long and low type at the southern margin of the belt, and the shorter type at the northern margin there is a grada-

FIG. 27.—THE NORTHERN ENDS OF THREE OF THE NEW YORK DRUMLINS NEAR MONTEZUMA (PHOTOGRAPH BY W. B. GREENLEE).

tional form to which a student of Cornell University applied the descriptive name of "tadpole" drumlin. The northern end of such a drumlin resembles the northern type quite closely, while the southern end is a low ridge, and the two different parts are connected by a rather noticeable slope, somewhat like the southern

FIG. 28.—NORTHERN END OF A HIGH DRUMLIN AT MONTEZUMA, N. Y. (PHOTOGRAPH BY W. B. GREENLEE).

end of a New England drumlin. Hence the drumlinoid form, somewhat closely resembling the typical New England drumlin, quickly changes to a low and long ridge, causing a rather remarkably close resemblance to a tadpole body with the appended tail. Some of the New York drumlins are quite like the New England type in

form, and all so far studied are made of unstratified till. The question of the nature and origin of these drumlins is now under investigation, and it is probable that the intermediate "tadpole" forms will throw light upon the question of drumlin origin.

As in the case of all drumlins, the long axis is parallel to the direction of ice movement, which, in this section, was approximately southward. The material composing them seems to be till

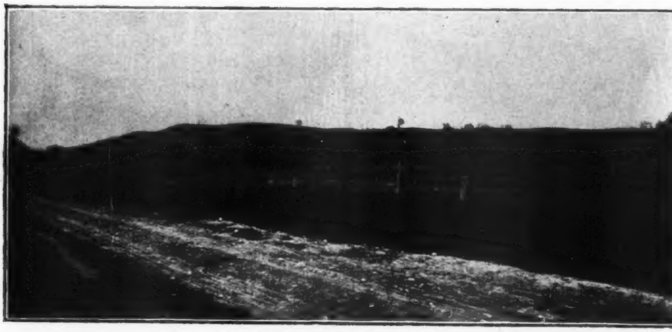

FIG. 29.—RIDGE-LIKE DRUMLIN, NEAR MONTEZUMA, N. Y., SHOWING NORTHERN END ON LEFT (PHOTOGRAPH BY J. O. MARTIN).

of the normal kind, perhaps somewhat more pebbly than commonly; but upon this point definite statements cannot be made until further studies have been carried on. Nor can we say how many drumlins there are, though it is certain that there are many hundreds in this area; and one may stand upon the crest of one and count scores which stand in plain view with their ends overlapping. The topography of the drumlin region is quite unique in New York State, and has probably given rise to more inquiries from residents than has any other section of the State of equal population. Every year several students ask me for the interpretation of this region, a fact true of no other part of the State.

The origin of drumlins is still an open question, or at least should be, though there is a tendency on the part of some to consider it settled. Numerous theories for their origin have been suggested,*

* See preceding references, and also Wright, Ice Age in North America, 251–267; Geikie, Great Ice Ace, 3rd Ed., 743–745; Russell, Glaciers of North America, 24–28; Geikie, Geol. Soc., Glasgow, 1867, Vol. III, 54; Wright, Proc. Boston Soc. Nat. Hist. XIX, 1876–78, 58; Salisbury, Ann. Rept. N. J. Geol. Survey, 1891, 71–75; Upham, Am. Geol., 1892, X, 339–362; Upham Am. Geol., 1895, XV, 194; Russell, Journ. of Geol., 1895, III, 831; Upham, Bull. Geol. Soc. Am., VII, 1896, 17–30; Tarr, Am. Geol., 1894, XIII, 393–407. In the latter, I have attempted to consider the two theories fairly, and have advocated the reopening of the question of origin.

two of which still seem probable, while against the others numerous facts can be brought. One of these theories is that drumlins have been caused by erosion, resulting from slightly different ice currents; the other, and more generally accepted theory, is that they have been *built* by irregular deposit from the ice, somewhat as sand-bars are built in rivers. The latter has more supporters than the former; but the question can hardly be considered closed, since no facts of importance have been brought forward to disprove the former. So far the theories have been stated as conceptions of the process which probably formed the hills. Careful studies of drumlin areas are now needed to test these theories, especially since there are facts difficult to explain upon the basis of the theory of construction which has so many adherents.

GLACIAL EROSION.—That the ice eroded is proved by the fact that it was able to deposit; for it must have obtained what it deposited, together with that which went off in the water furnished by ice melting. It is further proved by the scratched stones and the glacial scratches upon the ledges; but *how much* it eroded is more difficult to prove. The old notion was that ice performed wonderful tasks and greatly modified the topography as a result of this. From this extreme view there has been a reaction, and opinion has perhaps become nearly as extreme in the other direction, for there are those who deny to ice the power to do much work of this kind. That it did not erode enough to materially modify the surface in a *great* way, seems evident from an examination of the topography on the two sides of the extreme terminal moraine. Careful observation is necessary to detect the differences, which would not be the case had the ice scoured greatly in the glaciated district.

One thing every one will admit is, that in most places the ice removed the loose *débris* that had accumulated in preglacial times; still there are places in New England, and probably also in New York, where this was not done. This also argues against extreme glacial erosion; but these facts may be admitted without necessitating the view that erosion was everywhere slight.*

All facts, as I see them, indicate marked difference in power of erosion in different places. The hilltops were scoured more than the east-west valleys, and in all probability the hilltops of central and western New York were perceptibly lowered by ice-scouring. The proof of this would be difficult, for we know absolutely nothing of the detailed conditions before the ice came.

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* See Lincoln Proc. Am. Assoc. Adv. Sci., 1893, XLII, 177–8; Same, Am. Journ. Sci., Ser. III, 1892, XLIV, 290–301; Same, 1894, XLVII, 105–113.

FIG. 30.—GLACIATED SURFACE OF UPPER NUGSUAK PENINSULA, GREENLÄND, SHOWING SMOOTHED NORTH SIDE AND STEEP SOUTH SIDE OF A HILL CALLED THE DEVIL'S THUMB ON THE DANISH MAP (PHOTOGRAPH BY J. O. MARTIN).

East-west valleys of narrow width, being transverse to the ice direction, were probably less eroded; but broad north and south valleys, like those of the Finger Lakes,* furnishing free passage to the ice, were perceptibly lowered and broadened. In such places I believe that we find the maximum ice erosion. It is in broad valleys extending in the direction of the ice movement that we find the most rapid ice movement, and hence erosion, at the margin of the existing Greenland glaciers. This is true not merely because of the breadth, but because the ice was deep in these valleys, and had a free and hence more rapid movement. These facts would seem to be sufficient proof of this view.

There was also more rapid erosion upon the north or *stoss* side of hills than upon the southern or *lee* side, against which the ice-currents had little chance to scour. That this is so is amply proved by the topography of New York and other regions, where the northern slope of hills is prevailingly more regular and rounded than the southern sides. The differences may amount to a difference between an inaccessible precipice on the southern and a gentle slope on the northern side of hills. This is beautifully shown in the Adirondacks, as it is also in New Hampshire and Maine, as well as in Greenland, where the ice has just left the land.

Therefore, it seems that by erosion the hilltops have been slightly lowered and rounded, hill-slopes modified and rounded upon the northern or stoss end, and broad valleys parallel to the direction of ice movement both broadened and deepened. If it were necessary ample proof of this position could be brought forward. This is a belief in moderate but irregular erosion, by which the topography of the State has been perceptibly modified in details; but to *just* what extent this modification has operated, how much the hills have been lowered and rounded and the valleys deepened, may never be determined.

EFFECT UPON DRAINAGE.—Of all the effects of the glacier this is probably the most notable. Lakes have been formed and allowed to disappear. Others now existing have been caused by one or another of the effects of the glacier. Streams have been turned temporarily across divides and others given permanently to different streams, while many have been turned either partly or wholly out of their old valleys. The drainage of New York is the complex result of preglacial topography and glacial modification. The consideration of this important effect of the ice must be left for later parts of this series.

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* This question will be discussed much more fully in a later number of this series.

GEOGRAPHY OF THE LAURENTIAN BASIN.

BY

ISRAEL C. RUSSELL.

The region surrounding the Laurentian Lakes, or Great Lakes as they are more commonly termed, is of low relief. No mountains, unless the Adirondack Hills be dignified by that name, rise within its borders, and no summit furnishes sufficiently commanding views to enable one to judge of the relations of the topographical details throughout any considerable portion of that area. The geographical history of the region has to be patiently compiled from the reports of numerous observers who have explored the land and sounded the waters. The difficulties encountered in deciphering the records of past changes, on account of the low relief, are enhanced by the general covering of vegetation.

Before attempting to review the leading features in the geographical history of the region to which attention is here invited, it is important that we should have in mind certain facts respecting the lakes themselves as they exist to-day. In order to present some of these data in convenient form, the following table, compiled principally from the reports of the U. S. Lake Survey, is inserted:

LAURENTIAN LAKES.

NAMES OF WATER AREAS.	AREAS IN SQUARE MILES.			MEASURES IN FEET.			
	WATER SURFACE.	WATER-SHED.	HYDRO-GRAPHIC BASIN.	MEAN ELEVATION.	MEAN DEPTH.	MAXIMUM DEPTH.	DEPTH BELOW SEA-LEVEL.
Lake Superior...........	31,506	51,600	83,106	602	475	1,008	406
St. Mary's River.......	150	800	950	...	...	...	...
Lake Michigan..........	22,450	37,700	60,150	581	325	870	289
Lake Huron............	23,800	31,700	55,500	581	250	730	149
St. Clair River..........	25	3,800	3,825	...	...	...	...
Lake St. Clair...........	410	3,400	3,810	...	...	...	...
Detroit River....... ...	25	1,200	1,225	...	...	...	...
Lake Erie..............	9,960	22,700	32,660	573	70	210	...
Niagara River..........	15	300	315	...	...	...	...
Lake Ontario..........	7,240	21,600	28,840	247	300	738	491
Total........	95,581	174,800	270,381	...	...	...	...

As may be seen from this table, the lakes are of broad extent in reference to the area of the hydrographic basin in which they are situated. The ratio of lake surface to water-shed is as 1 to 1.82. It has been found that the depth of water removed from the lakes each year by evaporation is in the neighborhood of 30 inches, or nearly equivalent to the direct contribution from the clouds—the average annual precipitation being about 35 inches. The discharge through the St. Lawrence, therefore, represents approximately the excess of rainfall over evaporation from the land area draining to it.

The water discharged by the several lakes, is as follows:*

St. Mary's River, outlet of Lake Superior	86,000	cu. ft.	per second.
St. Clair River, outlet of Lakes Michigan and Huron	235,000	"	"
Niagara River, outlet of Lake Erie	265,000	"	"
St. Lawrence River, outlet of Lake Ontario	300,000	"	"

The combined volume of water in the Laurentian Lakes is 6,000 cubic miles, or sufficient to maintain Niagara Falls for 100 years.

Such are some of the leading facts in the physical geography of the Laurentian Lakes as they have existed since first known to white men. Much evidence has been obtained in reference to the manner in which these conditions have been brought about, and it has been found that the Laurentian basin has a long and remarkably varied history. This geographical history may for convenience be divided into three portions—ancient, mediæval and modern—in much the same way that human history is thus divided. The first division embraces the vast lapse of time preceding the Glacial epoch, during which the region under consideration was a land area; the second division includes the time from the first invasion of the Laurentian Basin by the ice of the Glacial epoch to the stage in the retreat of the ice when it began to be permanently uncovered; and in the third division are placed the changes that have occurred since the last ice sheet withdrew from the southern margin of the region now draining to the Great Lakes.

The Lake Region in Pre-Glacial Time.—The hydrographic basin of the St. Lawrence, in common with a vast area surrounding it, is almost everywhere covered by a sheet of unconsolidated gravel, clay, etc., of glacial origin, as will be more fully explained in ad-

* L. Y. Schermerhorn, "Physical Features of the Northern and Northwestern Lakes," in American Journal of Science, 3d Series, Vol. 33, 1887, pp. 278–284.

vance. The thickness of this covering varies from a few feet to one hundred or even a hundred and fifty or more feet. About the immediate borders of the present Great Lakes there is a belt of country, in several places from twenty to forty miles broad, which was formerly occupied by the lakes when more widely expanded in certain directions than now, and became covered with stratified clays and sands, which were spread out at the bottoms of the old water bodies. The depth of this covering is frequently from forty to sixty feet, but its maximum thickness is unknown.

The superficial deposits just referred to conceal by far the greater portion of the underlying hard-rock topography, as it may be conveniently termed. Could this covering be stripped off, the surfaces of the rocks beneath would reveal the broader features, and in many instances the smaller valleys, hills and ridges which gave expression to the land before the coming of the glaciers. This buried surface of hard rock, consisting mostly of sandstone, shale and limestone, retains to a considerable extent the topographic features that resulted from erosion previous to the Glacial epoch, and furnishes evidence as to the changes which inscribed their records on the surface of the land in pre-glacial time.

In places the hard rocks project above the mantle of superficial material spread over them, and at other localities streams have cut down their channels through the surface layer so as to expose the rocks beneath. Then, too, hundreds of borings made in quest of coal, oil, gas, water, salt, etc., furnish valuable information concerning the depth of the superficial covering, and consequently in reference to the shape of the surface on which it rests.

The bold escarpment of limestone with shale beneath, which occurs adjacent to the southern shore of Lake Ontario, and a similar line of cliffs along the south side of Lake Erie, are remnants of topographic forms that existed previous to the Glacial epoch. The faces and edges of these escarpments are smoothed and striated in such a manner as to show that they offered stubborn resistance to the ice currents which came against them from the north. Other ridges and hills on the border of Lake Superior furnish additional data of the same nature. Some knowledge is thus had concerning the bolder topographic features of the Lake Region during the earlier portion of its history. Many of the wells that have been drilled through the sheet of surface material reveal the presence of narrow cañon-like channels and valleys in the hard rock beneath, where the present surface shows only a plain or a gently undulating surface. Sufficient evidence of the nature just

indicated has been obtained to show that the land in the Lake Region previous to the Glacial epoch was of mild relief, but had been eroded by streams into a system of broad valleys now occupied in part by the Great Lakes, to which many deep, narrow stream-cut channels conducted the waters falling on the adjacent uplands. In brief, the land was not only well drained, but presented the characteristic features of old topography. Throughout much, and probably the whole of the Laurentian Basin, at the time referred to, the relief was similar to that characteristic of a certain portion of the upper Mississippi Basin at the present day, where broad, nearly flat-bottomed valleys, bordered by bold rock-escarpments, intervene between rolling but well-drained uplands. In fact, in what is known as the "driftless area" in Wisconsin and Minnesota, embracing some 10,000 square miles, we have a remnant of pre-glacial topography not modified by ice action.

The length of time to which the land was subjected to weathering and erosion previous to the Glacial epoch cannot be measured in years, but was surely great. This is shown not only by the topographic forms produced by the slowly-acting erosive-agencies, but by the absence of rocks of late geological age. With the exception of a partial submergence of its extreme western portion during Cretaceous time, the entire Lake Region has been a land area since the Coal period. During this vast interval embracing probably a third or a fourth of the time included in what may be termed authentic geological history, the Lake Region in common with probably the whole of North America enjoyed a mild if not a sub-tropical climate and was clothed with luxuriant forests, including palms, and was inhabited by a long succession of strange reptiles and mammals all of which are now extinct.

Of this ancient history of the Lake Region, the only immediate records available are furnished by the hard-rock topography. Sediments of Tertiary lakes, like those in the far West in which so much evidence has been found bearing on the climatic condition of America in later geological time and on previous faunas and floras, are absent in the country drained by the St. Lawrence.

The Lake Region during Glacial Times.—The fair picture of broad valleys, bordered by stream-sculptured uplands and clothed throughout with forests comparable with those of the virgin lands of the Gulf States, presented by the Lake Region in late Tertiary time, was blotted out owing to a climatic change which caused glaciers of vast extent to flow from the north and cover it. The previous almost tropical luxuriance was replaced by desolation like that which

reigns at the present day in central Greenland. An ice sheet many hundreds of feet in thickness overspread the land and reached as far south as Cincinnati and central Kansas. A change to milder climatic conditions caused this first ice sheet to retreat, probably to the north of the site of the present Great Lakes, but evidence as to the full extent of this recession is lacking. As is well known, another ice advance followed the first stage of retreat, or the first interglacial stage, as it is termed. Succeeding this second advance, came another retreat and then a third advance. Each southward movement of the ice caused the entire Laurentian basin to be covered.

The condition of the basins of the Great Lakes during the interglacial stages of warm climate, is not fully known for the reason that subsequent ice advances, in each instance, blotted out such records as may have been made. In one locality, however, on the north shore of Lake Ontario, near Toronto, there are stratified lacustral clays, containing shells of fresh-water mollusks, insects and plant remains, which are covered by glacial clays. These records show that during one of the latest-interglacial stages, the basin of Lake Ontario was free of ice and occupied by a lake. The vegetation clothing the northern shore of this lake included species now growing in New York and Pennsylvania.

With the final retreat of the glacial ice from the Laurentian basin, what may be termed its modern history began.

The Lake Region in Post-Glacial Time.—As stated above, the ice sheet which covered northeastern North America during its last advance, had its southern margin to the south of the southern border of the present hydrographic basin of the St. Lawrence. To the south of the ice sheet the stream formed by its melting had an unobstructed flow southward. As the ice front retreated, however, there came a time when it withdrew to the north of the height-of-land now parting the streams flowing northward to Lake Erie, from those flowing southward to the Ohio and the Mississippi. This divide is an irregular east and west line; the southern border of the ice sheet was also an irregular east and west line. As the ice front receded, the divide was not uncovered all at once, but gradually, and lakes were found in the southern prolongation of the Laurentian basin from which the glacial ice was first melted.

Probably the first of these lakes to come into existence occupied the western end of the Erie basin, and overflowed southward through a channel beginning where Fort Wayne, Indiana, is now situated, and leading to the Mississippi. This lake has been named Lake Maumee, for the reason that a large portion of its basin is now

drained by Maumee River. It was small at first, but gradually broadened with the recession of the ice which formed its northeastern shore. One stage in its existence is shown on the accompanying sketch map, forming Fig. 1. The river which flowed from Lake Maumee was a mile wide, and the channel it carved is now occupied in part by the Wabash.

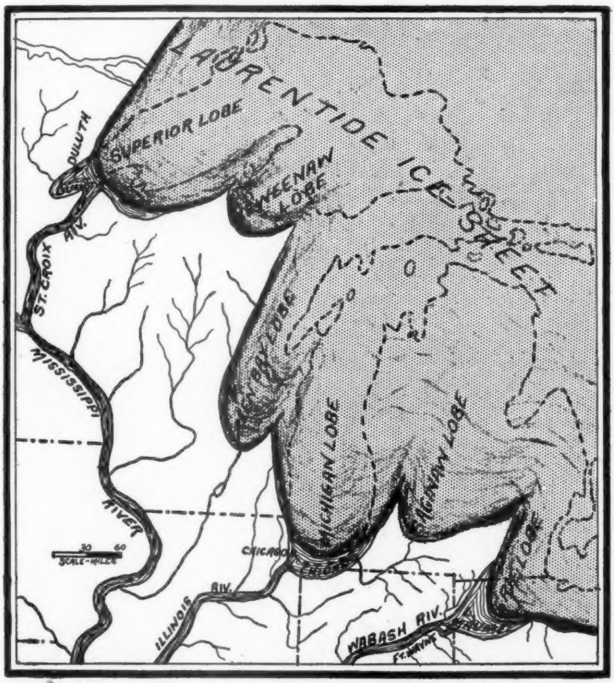


FIG. 1.—LAKES MAUMEE, CHICAGO AND DULUTH (REDRAWN FROM A MAP BY F. B. TAYLOR).

Soon after Lake Maumee came into existence, as has been shown by F. B. Taylor, C. R. Dryer and others, similar lakes were born at the south end of the Michigan basin and at the west end of the Superior basin. These lakes and the rivers that drained them are also represented on the map reproduced above. The three lakes thus far considered, were independent of each other, and were situated at different levels and all discharged southward to the Mississippi.

The ice front continuing to recede, there came a time when land to the northwest of the site of Detroit was uncovered, and an out-

let for the waters of Lake Maumee, lower than the Fort Wayne outlet, became available. Lake Maumee then discharged to Lake Chicago, across southern Michigan, and its water surface fell about

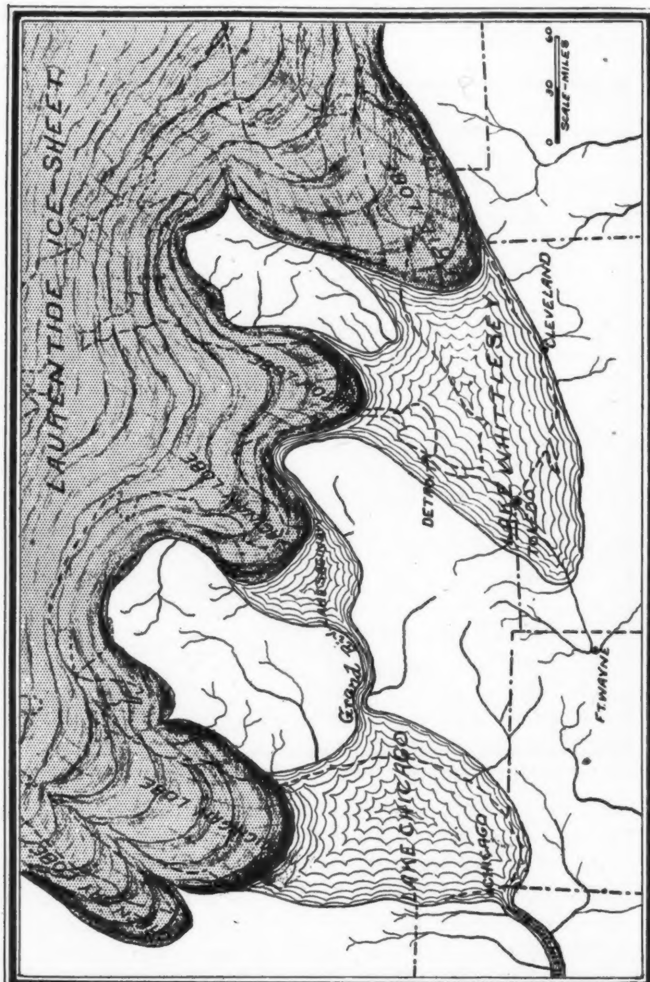


FIG. 2.—LAKES WHITTLESEY, SAGINAW AND CHICAGO (REDRAWN FROM A MAP BY F. B. TAYLOR).

twenty-five feet. After this change the water-body in the western end of the Erie basin was greatly changed, and became essentially

a new lake. The recession of the ice northward allowed the waters to expand, and a still lower outlet across Michigan was uncovered. For this stage in the condition of the water-body in the western parts of the Erie basin the name Lake Whittlesey has been given, as shown on the map forming Fig. 2.

At this time Lake Chicago was also much enlarged, although still discharging across its southern rim through the broad channel now occupied in part by Des Plaines and Illinois rivers. Another marginal lake existed at this time in Saginaw valley.

As has been described by Taylor, at the next step in the retreat of the ice front, Lake Whittlesey fell and blended with Lake Saginaw. This new combination is called Lake Warren. The outlines of this lake also slowly changed with the recession of the ice, and at one stage had the general characteristics shown in the map forming Fig. 3. Many other modifications occurred in the lakes held in by the glacial dams, but it is not possible to follow these minor changes at this time.

FIG. 3.—LAKES CHICAGO AND WARREN: OUTLET AT CHICAGO (MAP BY F. B. TAYLOR).*

At a considerably later stage in the retreat of the ice, the Mohawk valley in New York became uncovered, and the great lake formed by the expansion of several water-bodies like those briefly described above, found an outlet through the Mohawk-Hudson valley and the former outlet at Chicago was abandoned. As stated by Taylor, the discharge of Lake Warren then turned eastward and the

* The name *Labrador ice-sheet* used in this map is synonymous with *Laurentide ice-sheet* on accompanying map.

level of the waters fell so as to uncover the land between Lake Huron and Lake Erie. Across this area, now included in Ontario, the waters of the western lakes began to flow. With the drawing

FIG. 4.—LAKE ALGONQUIN, TRENT RIVER, AND LAKE IROQUOIS: OUTLET THROUGH THE MOHAWK VALLEY (REDRAWN FROM A MAP BY F. B. TAYLOR).

off of the waters through the Mohawk valley, the lake in the Ontario basin fell below the level of Lake Erie and Niagara River with its magnificent cataract came into existence. About the same

time, or soon after the fall of Lake Warren, the ice had so far withdrawn from the northern basins as to allow the waters of Lakes Michigan and Huron to unite as one lake with its outlet through the St. Clair river to Lake Erie. This great lake named Lake Algonquin is shown on the map forming Fig. 4. The contemporary lake in the Ontario basin was larger than the present Lake Ontario, and is known as Lake Iroquois.

An interesting stage in the history of the Laurentian basin is illustrated by the map forming Fig. 4, when, owing to movements in the land, Lake Algonquin discharged through the valley now occupied by Trent River. This old channel, in common with others of a similar character, will be referred to later in connection with the influence of the geography of the Lake Region on travel and commerce.

At a still later stage in the changes we are reviewing, the ice withdrew so as to uncover the channel now occupied by the St. Lawrence, and a pre-glacial avenue of drainage of great antiquity became available. The water surface of Lake Iroquois fell, the Mohawk Valley as an avenue of discharge for the drainage of the Great Lakes was abandoned, and the modern St. Lawrence River came into existence. The St. Lawrence follows in general the course occupied by a greater St. Lawrence, which drained certainly a large portion of the Lake Region in pre-glacial time. The northeastern portion of the continent, for a long period during its pre-glacial history, was higher than now by at least 600 or 1,000 feet. The continental border was then about two hundred miles east of Nova Scotia, and the mouth of the Greater St. Lawrence, as has been shown especially by J. W. Spencer, was well to the east of Cape Breton. The Greater St. Lawrence and its principal branches were long lived and deeply entrenched themselves. In post-glacial time a subsidence of the land allowed the sea to encroach on the border of the continent, and the entire extent of the Greater St. Lawrence, the Ontario basin, and a portion of the Ottawa Valley were in direct communication with the sea. At this same stage a narrow strait connected the valleys of Lake Champlain and Hudson River, thus making New England an island. This stage in the history is indicated on the map forming Fig. 5.

All of the valleys, submerged by the subsidence of the land after the retreat of the glaciers, had been excavated in pre-glacial time to a depth greater than they now have. The broader features in what has been termed the hard-rock topography, brought into prominence by this submergence, speak as forcibly as do the broad

basins in the central and western portions of the Lake Region, of the great amount of erosion the land underwent before the coming of the glaciers, and of the immense length of time during which its surface has been above the sea.

FIG. 5.—THE NIPISSING LAKES, DISCHARGING THROUGH OTTAWA VALLEY TO CHAMPLAIN SEA OR ESTUARY: HUDSON AND CHAMPLAIN VALLEYS SUBMERGED (REDRAWN FROM A MAP BY F. B. TAYLOR).

Subsequent to the stage indicated in Fig. 5 the land again rose, but not to its previous altitude, and the Ontario and Champlain basins were converted into seas occupied by ocean waters. The flooding out

of the salt water has converted these basins into fresh-water lakes. The rise of the land referred to was not sufficient to reclaim the St. Lawrence and Hudson valleys completely, and in the former tide-water now reaches nearly to Montreal and in the latter to Troy.

By referring to Fig. 5, it will be seen that at the stage in this long history there represented, the basins now occupied by Lakes Huron, Michigan and Superior discharged their surplus water through the channel of the Ottawa; movements in the land having diverted the drainage of these basins from the St. Clair River and Lake Erie. During this time, as has been shown by Taylor and others, Niagara Falls lost much of their grandeur.

We speak with confidence concerning the movements in the earth's crust which caused the old lakes to shift their place of discharge, since similar movements are now known to be in progress. The recent change referred to, as has been shown especially by G. K. Gilbert, is of the nature of a downward tilting of the region occupied by the Great Lakes toward the southwest or an upward tilting toward the northeast at a mean rate of .42 of one foot per 100 miles in a century. The bed of the old outlet at Chicago, at the summit of the pass, is but 8 feet above the mean level of Lake Michigan and 5 feet above the highest stage of the lake recorded in recent years. The present rate of land movement continuing, the lake during high water stages will reach the pass in 500 or 600 years, in 1,000 years the discharge will occur at ordinary water stages, and after 1,500 will be continuous. In 2,500 years Niagara will have become an intermittent stream, and in 3,000 years all of its waters will have been diverted to the Chicago outlet.

As may be gathered from this hasty review, the basins of the Great Lakes as they now exist, owe their origin not to a single cause, but to the combined action of at least four agencies. These are: stream erosion which excavated broad depressions; movements in the earth's crust, which tilted the rocks so as to obstruct the free drainage of the valleys; glacial erosion, and what is of more importance, the deposits made by the invading ice sheets. When the glaciers finally withdrew the surface of the region they occupied, more especially in a belt about a hundred miles in general width along its southern margin, was left with a heavy covering of boulder clay, gravel, etc. This covering modified the direction of the streams in many ways, and caused not only the larger valleys to be dammed, but gave origin to thousands of small lakes. The former streams were thrown out of their previously deeply eroded channels in many instances, and had to begin their tasks anew.

These rejuvenated streams have, as yet, made but little advance in the work of cutting down their channels to the level of the still water into which they flow, and are characterized by the presence of innumerable water-falls and rapids.

The land drained by the St. Lawrence is, for this reason, a region of cascades. The grandest of these, Niagara, has cut back a cañon about seven miles long, but all of this task was not performed since the lowering of the surface of Lake Warren. Niagara is too well known, from the writings of Gilbert, Taylor and others, to require special attention at this time. Its magnificence detracts from the attention that would otherwise be given to the many picturesque cascades, especially of New York and Canada, which came into existence at about the same time as its own birth, and have somewhat similar histories.

This abundance of water power, left as one of the many inheritances from the Glacial epoch, has led to the establishment of numerous factories, and the growth of villages and towns; and for this reason the influence of the Glacial epoch on industrial arts is nearly as important as its bearing on agriculture and commerce.

Immediately surrounding the Great Lakes in many places, as, for example, in the Maumee Valley, at the head of Saginaw Bay, over much of Ontario, etc., there are broad tracts of nearly level land left bare by the recession of the former water-bodies. These flat areas are underlain, as previously stated, by a considerable depth of stratified clay, which was deposited as sediment from the ancient lakes.

INFLUENCE OF GEOGRAPHICAL CONDITIONS ON EXPLORATION AND SETTLEMENT.

The numerous geographical changes briefly sketched in the preceding pages, left the Lake Region with certain pronounced characteristics, which have had a direct and intimate bearing on the lives not only of its aboriginal inhabitants, but of European immigrants as well. The geographical features of most marked importance in this connection are those due to (1) pre-glacial stream-erosion, (2) glacial deposition, (3) post-glacial stream-erosion, and (4) movements in the earth's crust. The first established the general courses of the great rivers, both within the present basin of the St. Lawrence, and on its borders, and produced the broad valleys, since dammed and converted into lakes; the second spread a deep mantle of broken and comminuted rock *débris* over the entire area, partially filling the valleys and obstructing their drainage; the third led to the excavations of many valleys, especially those occupied

by the streams draining ice-dammed lakes; and the fourth produced important changes in the lakes, and caused the sea to invade the low lands in the eastern part of the Lake Region.

The main influence of these many changes on the aborigines was of course in the production of the Great Lakes, on the shore of which many Indian tribes had their homes. The lines of communication furnished by the valley and streams, the fishes of the lakes and rivers, the forests on the land, with their abundant animal life, and to a limited extent, the favorable condition as respects soil and climate for agriculture, all had a direct bearing on the lives and development of the uncivilized tribes, but may be better illustrated by the rapid advance and marvellous growth of European colonies.

Of the main geographical features referred to above, the last, namely, the drowning of the St. Lawrence valley by an advance of the sea far inland, was the first to exert its influence on the history of civilization.

In 1534, Cartier entered the broad estuary of the St. Lawrence and ascended it with his ships as far as the site of Quebec. Continuing his explorations in open boats, he succeeded in reaching the bold mountain at the base of which Montreal now stands. The hope of discovering the much-sought-for northwest passage was blighted when tide-water was passed, and the great river of which the estuary is a continuation was entered.

A minor influence of topography on both native peoples and on French exploration and settlement, is illustrated by the fact that Cartier found an Indian village at the mouth of the Saguenay, another at the site of Quebec, and a third where Montreal has since been built. Each of these localities also marks a stage in the travels of the first band of Europeans to see the beautiful shores of the St. Lawrence. The Indian village known to the French as Tadousac, at the mouth of the Saguenay, and Hochelaga, at the junction of the Ottawa with its master stream, were in the days of Indian warfare, as at the present time, strategic localities, which commanded lines of travel branching from the St. Lawrence highway. What was probably equally determinative in the selection of those village sites as well as the one where Quebec now stands, was the occurrence of conspicuous land marks at each locality. Although the promontories referred to do not appear themselves to have been occupied by Indian villages, they no doubt afforded look-out stations, and were besides mile-stones in river navigation and definite localities in the wilderness, easy of description and location, and suitable for meeting places. In traversing a region of generally

mild relief, as all travellers in a wild country are aware, an isolated promontory attracts one toward it, even if he has no definite aim in view. Even without special arrangement prominent land-marks determine halting places. For these several reasons Indians travelling in their canoes centuries ago determined the sites of the great cities of Canada.

Following Cartier came Champlain, who greatly extended the claims of France in the New World. In 1609, he discovered the splendid lake now bearing his name, reaching it by way of the ancient valley through which its waters flow to the St. Lawrence. This line of communication leading from the St. Lawrence to the Hudson, which was excavated by a river in pre-glacial time, and occupied by the sea after the last retreat of the glaciers, was first traversed from tide-water in the St. Lawrence estuary to tide-water in the Hudson estuary by Father Jogues, one of the most intrepid of Jesuit missionaries. Later, it became a well-trodden route for French and English both in times of peace and war. Its importance in war is recorded by Ticonderoga, Bemis Heights and Saratoga. Commerce and travel have followed the paths marked out by natural conditions for Indian war parties and French and English armies. Railroads and canals now connect the St. Lawrence and Hudson estuaries by way of this historic pass.

In 1613, the first white man, Father Joseph Le Caron, ascended the Ottawa, and was followed the same year by Champlain, who made a second journey by the same route a year later, and discovered Lake Huron. This line of travel, from Montreal up the Ottawa to Lake Nipissing and thence down French River to the "Mer Douce," it will be remembered, ascends the course of one of the outlet streams of Lake Algonquin. This route, although beset with many difficulties, it is safe to say would not have been available even for canoe navigation but for the work done by the river that formerly flowed along it and prepared a way by which the Indians of the Northwest could avoid their enemies, the Iroquois, who occupied central New York and made travelling dangerous on Lakes Ontario and Erie. This same Ottawa route, cutting across the great detour made by the waters of the Upper Great Lakes at the present day in order to make their plunge over the Niagara escarpment, was chosen in recent years for the trans-continental railroad of Canada. The valley of the Trent, once the outlet of Lake Algonquin, was traversed by Champlain and his Indian allies, while on his way to attack the stronghold of the Iroquois in northern New York. In 1641, Father Jogues, undaunted by his previous

experience among the Mohawk Indians, reached Sault Ste. Marie. The importance of the line of travel then discovered, and the great influence it has had on the commerce and development of the entire Northwest, will be more fully considered in advance.

Fathers Marquette and Joliet, in returning eastward after their arduous journey which made known the upper Mississippi, ascended what are now known as Illinois and Des Plaines Rivers, and reached the south end of Lake Michigan by way of the old river channel, carved by the waters flowing south from the Michigan basin. The divide left when the waters of Lake Warren were diverted from the outlet at the present site of Chicago to the Mohawk, as we have seen, is low, only eight feet at the summit above the normal stage of Lake Michigan. Accounts that have come down to us show that during the early settlement of northern Illinois this old outlet was so nearly restored during unusually high stages of the streams, that canoes and even rafts of logs could be taken through it. This channel, initialed by the stream flowing from Lake Chicago, was a much frequented portage in the days of canoes long before the coming of the French, and since that time has never ceased to increase in importance as a commercial thoroughfare. It is now being deepened and made suitable as a drainage canal for Chicago, and will no doubt in the near future become an important link in the waterway between the Mississippi and the St. Lawrence. As we have already noted, geologists have foretold the date at which this long-abandoned river bed will again be occupied if the slow changes in progress are not modified.

The river supplied by Lake Maumee carved a broad channel leading west from the present site of Fort Wayne, and as in the case of the similar stream flowing from Lake Chicago, furnished a favorite route for Indian travel. This was the easiest and best route for canoe navigation between Lake Erie and the region drained by the Mississippi. This same portage was used by the French and English during colonial days, and later, was included in one of the first railroad-routes to the West, and is still one of the great railroad thoroughfares of America. In northern Ohio and central New York there were several small lakes during the earlier stages of the final retreat of the ice of the Glacial epoch, of the same general character as Lake Maumee. Although no mention of these lakes was made in the brief sketch of the geographical history of the Lake Region previously given in this essay, yet, as is well known, their outflowing waters cut deep trenches across the divide now parting the waters flowing northward from those finding their way

southward to the Ohio, Susquehanna, etc. These passes are known to have been used by Indians, and especially by the Iroquois, in making raids into the lands of their enemies at the south. In these modern days of railroads, these same routes are in several instances traversed by shining bands of steel which unite the commerce of the North and South.

The most important of the outlet channels of the old lakes previous to the re-occupation of the St. Lawrence valley, was by way of the Mohawk and the Hudson. The valleys of these rivers are of ancient date, and have furnished the lines of stream transportation down which vast quantities of sediment have been carried from the land to form new deposits in the sea. The glaciers modified these old river-valleys to some extent by abrading their walls and bottoms, but the greatest changes produced by the ice occupation are due to the deposition of clay, boulders and other glacial refuse. Later, the rivers flowing from Lake Warren and from Lake Iroquois removed some of the material left by the glaciers, especially in the valley of the Mohawk, and made it more serviceable as a line of communication between the East and the West.

The Mohawk valley furnishes the only broad, low pass across the mountain belt adjacent to the Atlantic, south of the St. Lawrence, until, in Georgia, the southern end of the Appalachians is reached. This natural thoroughfare played an important part in the relations of Indian tribes, and, as history shows, exerted what may be termed a negative influence on the spread and interrelations of French and English colonies. The Mohawk valley and the plateau of central New York failed to influence the growth of the European colonies in the manner that might be expected from purely geographical considerations, for the reason that they were occupied by the most intractable and warlike tribes of Indians on the American continent. The Iroquois filled this gap in the mountains, and during the most critical period of colonial history separated the French from the English as effectually as did the rugged mountains to the southeast and northwest of their densely-forested hunting-grounds.

When once the power of the Iroquois was broken, the valley of the Mohawk invited the English colonists, and a tide of immigration which has not yet ceased, began to flow through it. The work of the river that drained Lakes Warren and Iroquois lightened the task of the engineers who planned the routes of the Erie Canal and the New York Central Railroad. Far-reaching plans for a deep waterway connecting the Great Lakes with the Atlantic, through

this thoroughfare and uniting the North with the South and the East with the West, are now being matured.

Even this brief outline of the intimate connection between geographical and human history, as illustrated by the region under review, is sufficient, I think, to show that in many ways the destinies of nations and the march of civilization have been directed and modified by seemingly unimportant geographical changes, initiated thousands of years before white men came upon the stage of action. But for the deep trench cut by the Greater St. Lawrence, French explorers would not have been able to make known the region of the Great Lakes before colonies were established on the New England coast. We cannot say that America would not have been fought over by Spain, France and England had there been no passes through the mountains bordering the Atlantic and no Glacial epoch, but the course of events under such conditions would certainly have been far different from what we now find recorded in history. The influence of the Appalachian Mountains in restricting the spread of the English colonies westward, and of the St. Lawrence estuary and the Great Lakes in inviting the French to extend their settlements indefinitely, is indicated by the dates of a few pregnant events in American history. For example, Cartier reached the site of Montreal, a thousand miles from the sea, in 1534, before more than a beginning had been made by the English in tracing the outline of the Atlantic coast, and seventy-three years before the planting of a colony at Jamestown; Detroit was founded in 1701, or fifteen years previous to the crossing of the Appalachians by Governor Spotswood. This much-lauded but tardy excursion of the Governor of Virginia occurred thirty-four years after La Salle had navigated the Mississippi from Illinois to the Gulf of Mexico. Many other intimate connections between the geographical history of America and the welfare of our ancestors and ourselves might be enumerated. These connections are not only broad and far-reaching, but in numerous instances have a direct and tangible bearing on minor events. Manufacturing towns have sprung up where pre-glacial streams were turned from their courses so as to furnish water-power; the drowning of river valleys has led to the growth of great cities at the heads of estuaries; ancient river valleys have furnished passes for canals and railroads; former lake-beds afford broad, level farm-lands; the terraces of deeply gravel-filled valleys have been chosen as sites for villages and cities; ancient valleys, dammed by glacial deposits, have been converted into lakes with a wealth of fish life, which afford

unrivaled ways for commerce—these and a thousand other connections between the present and the past, many of them still unrecognized by historians and statesmen, have guided the affairs of nations and to-day influence the routine of our lives.

MINERAL RESOURCES.

The various stores of what are termed mineral wealth in the Lake Region had but little importance to the Indians. Native copper was mined in a rude manner from natural outcrops; flint was obtained from loose boulders for arrow points and spear heads; ochres were used for paint; mica for personal decoration; clay was manufactured into rude pottery; and certain soft rocks were utilized for pipes. This brief catalogue could perhaps be slightly extended, but an exhaustive study would fail to show that the Aborigines had more than a slight knowledge of the marvellous mineral resources of their broad domain. With the advance of civilization greater and greater demands have been made on the stores of material and energy accumulated in the earth's crust.

In the Lake Region, the rocks, especially limestone, sandstone, granite and basalt, furnish an inexhaustible supply of building stone and road metal. Clays are abundant for the manufacture of all the coarser kinds of pottery and for tiles, bricks, etc. Kaolin is known to exist, but has not been utilized. Extensive deposits of marl and clay are available for cement. Limestone and gypsum are largely employed in New York, Ohio and Michigan for lime and plaster. Hydraulic limestone is quarried on an extensive scale at Buffalo. Salt occurs in vast quantities in New York, Ontario and Michigan, and is the basis of a great industry; in 1894 the output was in the neighborhood of twelve million barrels. Chemical works near Detroit, with millions of dollars invested, are producing sodium carbonate. Phosphates for fertilizers are mined in the crystalline rocks of Canada, and the same terranes yield gold in considerable quantities, although small in amount in comparison with many other regions in America. Coal seams occur in the southern peninsula of Michigan, but although giving promise of important development in the near future, now yield less than 100,000 tons a year. Gas and oil fields in Ontario and northwestern Ohio are well within the Laurentian basin. None of the industries based on the geological resources just mentioned, however, have reached the development of which they are capable. There sources of wealth may be said to be held in reserve for future generations.

The great industries which draw their raw materials from the geological resources of the Lake Region centre about its vast iron and copper deposits.

The principal iron mines, not considering for the present the red ores of the Clinton rocks from New York westward to Wisconsin, or the much more important magnetite deposits of the crystalline rocks of New York, are the vast beds of hematite and magnetite on the south shore of Lake Superior, and similar but as yet undeveloped ores in adjacent portions of Canada.

The deposits of native copper on the south shore of Lake Superior have made Michigan not only the leading copper-producing centre in the United States, but given her a controlling voice in the copper markets of the world. With the copper occur minor quantities of native silver.

The production of both iron and copper has been increasing ever since their development began, and there is no evidence that the maximum has been reached. The supply seems to be regulated solely by the demand. The above statements may perhaps seem too sanguine, but I believe are fully sustained by statistics which show that the copper mines of Michigan produced 101,410,277 pounds of copper in 1890. The iron ores shipped from Michigan and Minnesota in 1895 amounted to 89,678,897 tons, or considerably more than one-half of the total production of the United States for the same year.

AGRICULTURAL RESOURCES.

The agricultural resources of the Lake Region are too well known to require extended description at this time. The fairest portions of New York and Ontario, the former the most productive of the northeastern States, and the latter the richest province of Canada, lie within the area draining to Lakes Ontario and Erie. Northern Ohio, small portions of Indiana and Illinois, nearly the whole southern peninsula of Michigan, and the eastern portion of Wisconsin need but to be named to show the great agricultural interests to which space denies consideration.

The basis of this vast agricultural development, the greatest source of wealth and strength of the Lake Region, lies, first, in the rich and varied soil left by the glacial invasion, and, second, in the climate which is tempered to a marked degree by the equalizing influences of the Great Lakes.

Owing largely to the warming of the air in winter by the slow escape of heat from the Great Lakes, and the cooling effect of the

same water bodies in summer, by evaporation which supplies moisture to the air when most needed, the agricultural region just referred to is also a highly productive fruit-growing area. The apples, peaches, pears, grapes, etc., and berries of various kinds, grown on the shores of the Great Lakes, are unsurpassed in perfection of form and richness of flavor by any other portion of America.

FORESTS.

In its natural state practically the whole of the land draining to the St. Lawrence was forest covered. With the development of agriculture and the growth of towns and cities much of the native forest has been entirely removed, and the inroads of timber cutters have greatly modified those portions which have escaped complete destruction.

A remarkable feature of the primitive forest was the intimate commingling of hardwood trees, such as the oak, hickory, black walnut, elm, beech, maple, etc., with coniferous trees, of which several varieties of pine, spruce, cedar and tamarack were in greatest abundance. This meeting of the floras of northern and southern lands, owing to favorable soil and climatic conditions, rendered the dense forests of the Lake Region unrivalled both in beauty and in usefulness by those of any other portion of the continent.

The special characteristic of the primitive forests, so far as the interests of lumbermen were concerned, was the vast number and large size of the white pines. The forests of Michigan, especially, have become renowned for the great quantities of white-pine lumber afforded by them. The demand for this valuable wood was so great, and was met in such a ruthless manner, that the supply is nearly exhausted. In some of the counties of Michigan, which were once centres of the lumber trade, a white-pine tree of even average size is now a rarity. Since the decline of the pine as a basis of industry, other lumber-producing trees have come into demand. Hard wood, more especially oak, maple and hickory, is still obtainable and largely used, and softer wood, like that of the cottonwood and spruce, is now being extensively utilized for wood-pulp and other purposes.

In spite of the wholesale wastefulness that has characterized the lumber industry of the Lake Region, there is still hope that scientific forestry will be able to repair some of the damage that has been done, and so rejuvenate the forests that they will meet all

legitimate demands that may be made on them by future generations.

FISHERIES.

The waters of the Laurentian basin, as well as its land areas, yield a harvest for the sustenance of man. The streams and smaller lakes abound in fishes of several species such as the bass, perch, pickerel, brook trout, etc., valuable, not alone for food, but in furnishing sport and recreation for lovers of the rod. The great commercial supply of fishes, however, comes from the larger lakes.

Of the lake fishes the most abundant and the ones of greatest value are the trout, white fish, lake herring, pickerel, sturgeon and perch. The importance of these fresh-water fisheries as a source of food supply is indicated to some extent by the following statistics, obtained from the U. S. Fish Commission.

FISHERIES OF THE GREAT LAKES, 1895.

Men employed . . .	21,194.
Fish taken	99,842,076 pounds.
Value of the fish taken . .	$2,691,866.
Caviar	477,020 pounds.
Isinglass	7,257 "
Oil	17,435 gallons.

To this must be added the similar industry in Canadian waters, which makes the total annual product of the Great Lake fisheries over $4,500,000 in value.

The activity with which the fishing industry in the Great Lakes has been carried on during recent years, and the lack of forethought has led to somewhat critical conditions in reference to the permanence of the supply. Wasteful methods similar to those which characterize the lumber industry already referred to, have prevailed in the lakes as well as on the land. But in much the same way that scientific forestry gives promise of a reform, which will lead to the preservation of the wood-lands still remaining, and insure their becoming of continuous value, so scientific methods applied to the preservation and continuance of the fisheries will guarantee their permanence for generations to come.

COMMERCE.

The commerce of the Great Lakes perhaps illustrates better than any other industry not only the remarkable prosperity of the regions bordering on these fresh-water seas, but its rate of increase

furnishes a sure promise of a still more marvellous growth in the near future.

The first sailing vessel to be built on these inland waters was *Le Griffon*, constructed under La Salle's direction in 1679. Practically, however, the commerce of the Great Lakes did not begin until more than a century later, and received its greatest impetus in 1835, when steam was introduced.

Statistics are here more eloquent than words. The following table, showing the commerce which passed north and south through Detroit River in 1889, tells its own story:

COMMERCE OF THE DETROIT RIVER, 1889.

Vessels passing, 32,415. Tonnage, 19,646,000.

Three times the foreign trade of New York.

10,000,000 tons in excess of foreign trade of all United States ports.

3,000,000 tons in excess of foreign and coast trade of London and Liverpool.

COMMERCE OF DETROIT RIVER, 1894.

Vessels passing, 34,800. Tonnage, 26,120,000.

The present importance and the promise of future growth of the commerce of the Great Lakes may be illustrated from another point of view. The shipping of the world is estimated at 18,240,000 tons; of this 4,769,020 tons belong to the United States, and of these 1,483,068 tons are to be credited to the Great Lakes. In 1897, vessels aggregating 116,937 tons were launched at the ship yards of Cleveland, Detroit, Chicago, and other lake ports; while the increase to the shipping at both the Atlantic and Pacific ports of the United States, amounted to 115,296 tons. The total American steam tonnage has increased 816,000 tons during the last ten years; 590,000 tons of that increase belong to the lakes. To-day there are on the lakes 2,120 steam and 1,324 sailing vessels, under the American flags, and 748 steam and 556 sailing vessels belonging to Canada. In addition there are about 3,000 fishing-smacks, yachts and other small craft. Additional data in this same connection may be found in a highly instructive article by F. W. Fitzpatrick in *The Cosmopolitan* for May, 1898.

The reports of the Deep Waterway Association and of the Deep Waterways Commission furnish a means for constructing a curve to show graphically the rate of increase in the number of vessels engaged in the lake trade during the present decade, their tonnage, character and value of their freight, etc. Such a curve would show

a rapidly increasing rise throughout, with a marked upward tendency especially during the past ten years. In connection with this promise of still greater developments to come, there is the confident expectation that the Great Lakes will soon be connected with the Atlantic by deep waterways suitable for ocean-going steamers, and also with the steamboat navigation of the Mississippi.

DEEP WATERWAYS.

The national importance of the commerce of the Great Lakes has led to the consideration of wide-reaching plans for a deep waterway connection between these fresh-water seas and the Atlantic.

Such an outlet for the commerce of the Great Lakes is desirable, not only to secure cheaper rates for the transportation of grain produced in its southwestern part of the Laurentian basin and the far vaster wheat lands of the Upper Mississippi Valley and adjacent portions of Canada, and to afford a wider market for the ores and forest products of the Lake Superior region, but also for the greater development of the already extensive shipbuilding industries of the lake cities.

A beginning in the way of connecting the fresh with the salt seas has already been begun by the building of the Erie Canal, and by a series of still deeper canals constructed by the Canadian Government. Lakes Erie and Ontario, as is well known, are now united by Welland Canal, which is one link in a system embracing several canals between Lake Ontario and Montreal, by which vessels drawing about nine feet of water may pass to and fro between the St. Lawrence estuary and the Great Lakes. In these improvements the Canadian Government has already expended over sixty million dollars. Since the construction of the Welland Canal the tonnage of the lake shipping has so vastly increased that at the present time what may be considered as the normal sized vessels used on the Great Lakes, for either freight or passenger carriage, are denied not only an outlet to the ocean, but cannot pass between Lakes Erie and Ontario.

In order to facilitate lake commerce, and with a view also to an ultimate communication with the ocean, far-reaching plans of harbor and river improvements have been under way for many years by the United States Government. The rivers connecting Lakes Superior and Huron and Lakes Huron and Erie, have been deepened in places and canals excavated, so that at the present day vessels drawing 21 feet of water can pass from any one of the

upper Great Lakes to any other, but as yet Lake Ontario is shut out of this system.

The most important of the improvements just referred to are at the outlet of Lake Superior. St. Mary's River there makes a steep descent of 21 feet, forming the rapids known as Sault Ste. Marie. These falls were a serious hindrance even to canoe navigation, and necessitated a portage of about one mile. To obviate this difficulty a canal, 2,580 feet long and provided with a lock 8 feet 9 inches wide, was constructed on the Canadian side of the river in 1777–78, but so far as can be learned was in operation but a short time. Remains of this, the first canal in the Lake Region, are still to be seen. The next step in the improvement of navigation between Lakes Superior and Huron was the construction of a tramway on the American side, previous to 1850, for the transfer of goods and also for the portage of small boats. Oxen were used to move boats over the tramway, which was the first "ship railway," if it can be dignified by the name, in America.

In 1853, a ship canal was begun by the State of Michigan, and completed in 1855. This canal was 5,400 feet long, 100 feet wide and 12 feet deep, and was provided with two locks each 350 feet long, 70 feet wide and with 11½ feet of water on the sills. The ownership of this canal with its locks, etc., was transferred to the United States Government in 1881. Improvements were then made and a new lock finished. This lock, still in operation, is 515 feet long between the gates, 80 feet wide, narrowing to 60 feet at the gates, and has 17 feet of water on the sills under normal conditions. At times, however, vessels drawing over 14½ feet of water cannot pass. This lock was completed in 1881, and cost $2,150,000.

The growth of commerce soon demanded a deeper canal at the Sault, and in 1896 a third lock was completed, now known as the "Poe Lock," in honor of the distinguished engineer who had charge of the work. This new lock, built on the site of the old State-Lock, is 800 feet long, 100 feet wide, and has a depth of 21 feet of water on the sills of the gates. It cost over $5,000,000.

Rivalry between American and Canadian interest made it desirable to have a canal on the Canadian side of the Sault, and in 1895 the Canadian Government finished the construction of a canal with a lock similar to the Poe Lock, at a cost of about $4,000,000.

The importance of the commerce passing the St. Mary's Falls canal previous to the opening of the Poe and Canadian locks, is

shown below, together with certain comparisons with the commerce of the Suez Canal.

ST. MARY'S FALLS CANAL AND SUEZ CANAL, 1894.

St. Mary's, open	234 days	
Suez, open	365 days	
St. Mary's; No. of Vessels passing	14,491	
Tonnage		13,110,366
Suez; No. of Vessels passing	3,352	
Tonnage		8,039,105
St. Mary's in excess of Suez	11,139 vessels	
St. Mary's in excess of Suez	5,071,261 tonnage	
St. Mary's, 1897; Vessels passing	18,615	
Tonnage		16,299,061

Some idea of the character and value of the freight passing the "Soo" may be obtained from the following statistics:

ST. MARY'S FALLS CANAL, 1895.

Number of Vessels passing	17,956
Registered Tonnage	16,806,781 tons
Freight	15,062,580 tons

VALUE OF FREIGHT.

Coal	$6,993,351
Flour	33,386,632
Wheat	30,041,863
Grain, other than Wheat	4,164,374
Manufactured Iron	3,863,150
Pig Iron	346,788
Salt	202,439
Copper	21,490,400
Lumber	8,888,400
Silver Ore and Bullion	11,200
Building Stone	238,760
Unclassified Freight	27,798,480
Total	$159,575,119

The comparisons just made between the commerce of the "Soo" and of the Suez canal, however, are misleading in certain respects. For example, the voyages of the vessels passing between the Mediterranean and the Red Sea are much longer than those of the vessels plying to and from Lake Superior. The important difference

between "long and short hauls" here comes in. Again, the vessels engaged in the traffic of the Suez Canal are much larger on the average than those of the lakes, and their freight is of a higher grade, and of much greater value per ton. When one has all of these qualifying facts in mind, however, the vast importance of the commerce of the Great Lakes does not suffer from being contrasted with that of the greatest of deepwater ways now in operation.

The construction of deeper and deeper waterways between Lakes Superior and Huron has been followed in each instance by an increase in commerce and an enlargement of the vessels engaged in both passenger and freight transportation. The larger vessels now sailing the Great Lakes compare favorably with the best of ocean going vessels engaged in similar lines of traffic. The magnificent steamers the *Northwest* and *Northland*, plying between Buffalo and Duluth, a distance of nearly 1,000 miles, are each 388 ft. long, 44 ft. beam, and provided with twin screws and quadruple expansion engine of 7,000 indicated horse power. These steamers are handsomely appointed and in every way compare favorably with the average Atlantic liner. A voyage on one of them has all the fascination of an ocean journey with the inconvenience arising from heavy seas largely eliminated.

The largest freight steamer thus far built on the Great Lakes is the *William R. Lynn*, 420 ft. over all, 48 ft. beam, with a freight capacity of 6,800 tons.

An increase in depth of water in the locks at Sault Ste. Marie, would, in the opinion of competent judges, be immediately followed by still greater increase in the size of ships engaged in the freight traffic.

The canals and locks at the "Soo" are considered by far-sighted engineers and statesmen to be but a link in a chain which will ultimately furnish a deep-waterway connection between Lake Superior and the Atlantic. The desire to have such a connection made has become popular and is now claiming the attention of both the Canadian and United States governments. An International Deep Waterways Association, holding its first convention at Cleveland in 1895, was followed by the appointment of a Deep Waterway Commission by President Cleveland in 1897, consisting of James B. Angell, John E. Russell and Lyman E. Cooley, for the purpose of considering the project of a ship canal from the Great Lakes to the Atlantic, in all of its aspects. This Commission has made a preliminary study of the several routes available, and of some of the less extensive improvements necessary to bring all of the Great

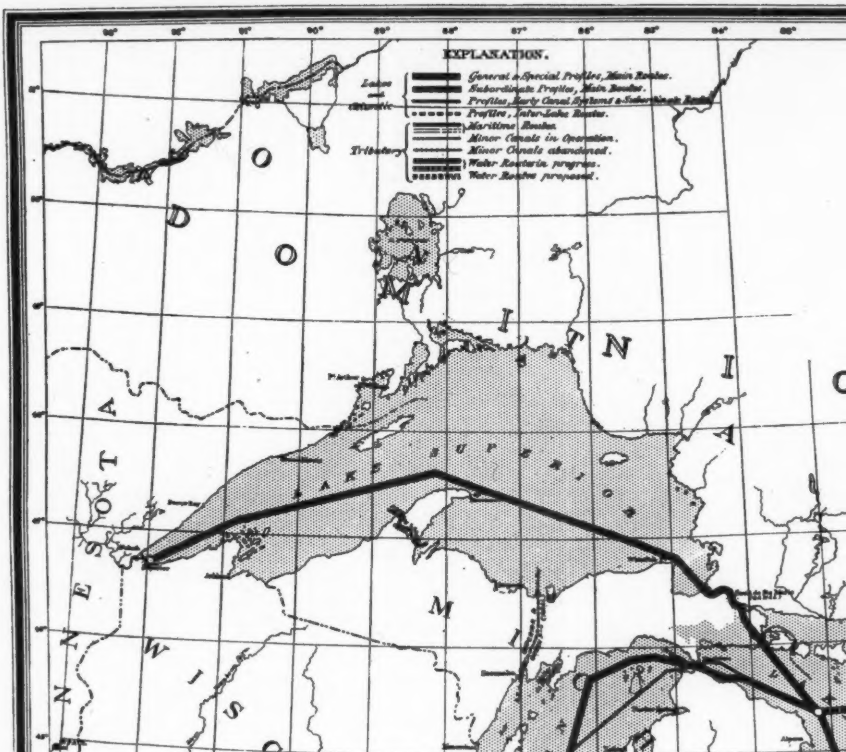

EXPLANATION.
General & Special Profiles, Main Routes.
Subordinate Profiles, Main Routes.
Profiles, Early Canal Systems & Subordinate Routes.
Profiles, Inter-Lake Routes.
Maritime Routes.
Minor Canals in Operation.
Minor Canals abandoned.
Water Routes in progress.
Water Routes proposed.
Tributary
LAKE SUPERIOR
DOMINION
MINNESOTA
WISCONSIN
MICHIGAN
IOWA
ILLINOIS
INDIANA

FIG. 6.—DEEP W

. 6.—DEEP WATERWAY ROUTES INVESTIGATED BY THE DEEP WATERWAYS COMMISSION, 1896.

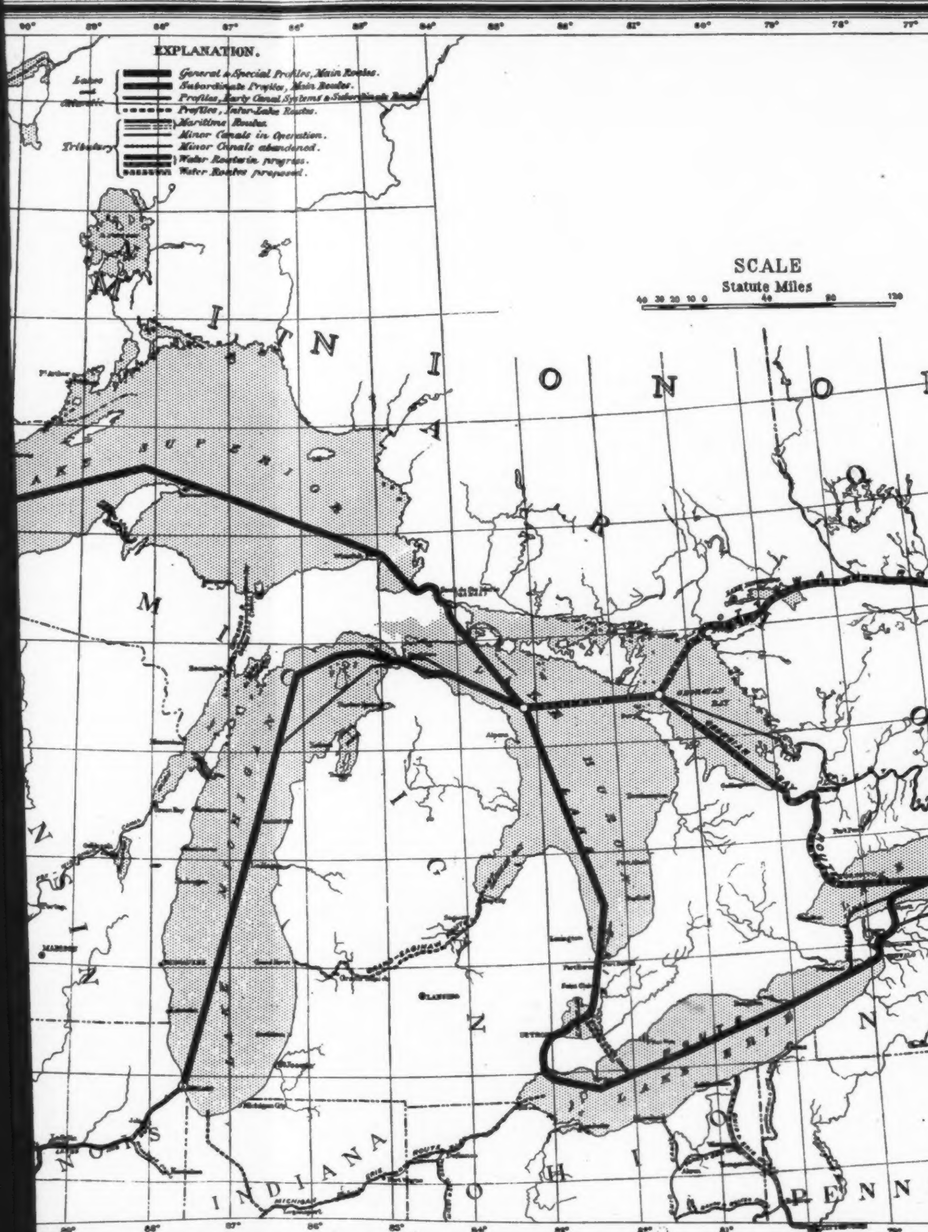
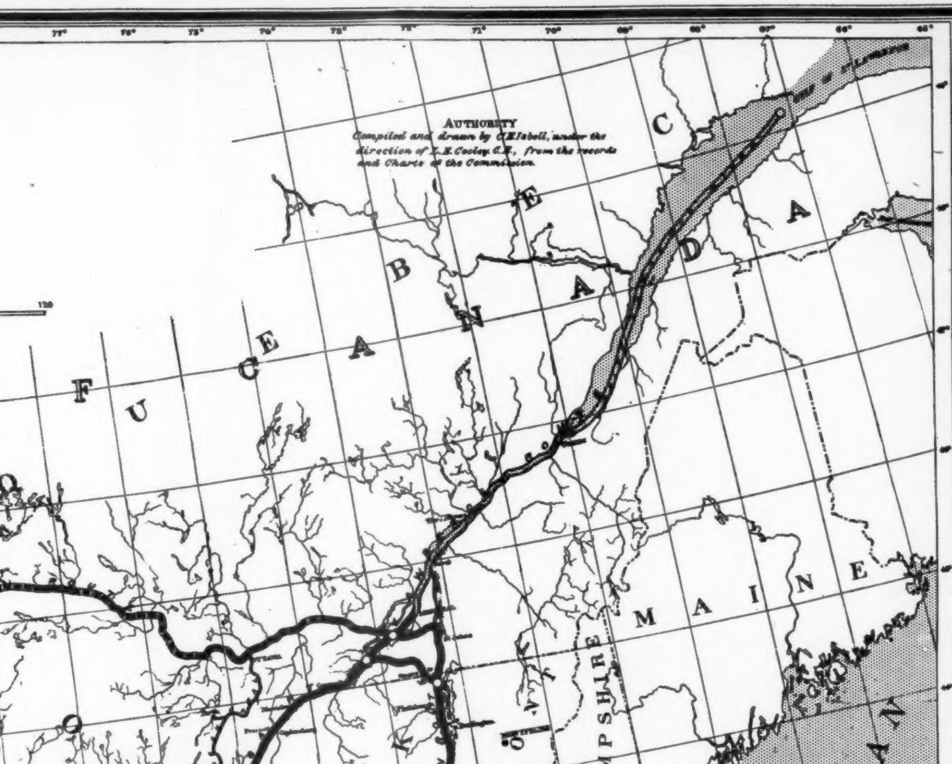


FIG. 6.—DEEP WATERWAY ROUTES INVESTIGATED BY THE DEEP WATE



E DEEP WATERWAYS COMMISSION, 1896.

Lakes into connection with ocean commerce. In the highly important report of the Commission a large amount of data bearing on the project under consideration has been issued.* A general map accompanying the report is reproduced on a reduced scale in Fig. 6. Without attempting to give even an abstract of the considerations bearing on the several routes that have been proposed, I may state that what is considered by several competent judges to be at the same time the most economical and most beneficial plan, contemplates the deepening of the existing waterway between Lakes Superior and Huron, and between Lake Huron and Lake Erie, so that a vessel drawing 31 feet of water may pass through them. Under this plan Lakes Erie and Ontario would have to be connected by a canal passing around Niagara Falls and Lake Erie connected with the Hudson River near Troy by a canal starting at Ogdensburg, New York, and leading to Lake Oneida, then through the Mohawk valley to the Hudson. Many considerations also favor an outlet by way of the St. Lawrence and a communication between the St. Lawrence and the Hudson by way of Lake Champlain.

. These several routes are indicated on the accompanying map, but space forbids an attempt to discuss their comparative merits at this time. It would be well, however, if the great project of grafting the commerce of the Laurentian Lakes on to that of the ocean could be widely discussed, as it is one to which statesmen as well as engineers and financiers will have to give careful consideration in the near future. The rate at which the Lake Region, and the country adjacent, especially on the south and west, is advancing in all that pertains to civilization, is abundant evidence of the desirability of increasing the facilities for transportation, and thus lessening the time and cost of placing the products of the "Old Northwest" in the markets of the world.

It is of interest to note that each of the routes to the sea discussed by the Deep Waterways Commission has a direct connection with the geographical history outlined on the earlier pages of this essay. Each route follows a line of ancient drainage, and has been influenced by changes in level. The Mohawk route owes its existence to the work of ancient streams, but suffered many changes, some favoring and others opposing the work of canal construction, during and since the Glacial epoch. The excavation performed by the river draining Lake Algonquin and more recent water bodies of the same general character did much to prepare the way for a

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* Report of the United States Deep Waterway Commission, Washington, 1897, 54th Congress, 2d Session. House of Representatives, Document No. 192.

ship-canal, by which the waters of the Ontario basin and the Hudson may again be united. The St. Lawrence and Champlain route has been modified, especially by the deposition of heavy beds of clay, sand and gravel, during the time when the Hudson-Champlain valley was an arm of the sea. These deposits have partially filled the old channels, and, on the whole, lead to conditions which make the excavation of a ship-canal more difficult than it would have been had a drowning of the old valleys not occurred.

The fact that the geographical development of the Lake Region has, on the whole, been highly favorable for human progress, is shown not only by the advantages that have been taken of the natural resources and the growth of commerce, but in many other ways. Schools, colleges and universities have been established, which are doing a splendid work in the way of disseminating knowledge and stimulating intellectual activity.

The marvellous advance of the Lake Region in population, wealth and intelligence is indicated—at least to all persons who have some knowledge of the region—by the statement based on the latest census, that it has upwards of eight millions of inhabitants, and includes such flourishing cities as Rochester, Syracuse, Toronto, Buffalo, Cleveland, Toledo, Detroit, Milwaukee, Chicago, Marquette and Duluth.

With the harmony and community of interests that exists between Canada and the United States, it is safe to predict that more marvellous development of the Lake Region, which, instead of dividing, unites these two countries of the same blood, will be witnessed during the twentieth century than has been attained since the days of Cartier, Champlain, Jogues, La Salle, Marquette, Joliet, and many other explorers, missionaries and traders, who gave their energies, and in many instances their lives, to the task of extending the influence of France and the Church. Instead of winning a race of barbarians to the Cross, as was the chief aim of the French, a way was prepared for a higher and better civilization than the world has yet known.

WASHINGTON LETTER.

WASHINGTON, D. C., JUNE 10, 1898.

ALASKA SURVEYS.—The Geological Survey party, under Mr. George H. Eldridge, reached the head of Cook Inlet on April 27. They found at that time the ice in Sushitna River about to break, so that they hoped to be able to ascend the river by the middle of May. It was planned to detach a party under the direction of Mr. Spurr when they should reach a tributary reported as coming in from the west about 30 miles from the mouth. This small party is to cross the divide to the Kuskokwim, descending this river and possibly making the lower portage to Yukon River and rejoining the main camp at St. Michaels in September, or, possibly, should circumstances permit, turn toward the south to Bristol Bay, and from there reach St. Paul on Kadiak Island.

The principal party under Mr. Eldridge was, at the time he wrote, to go up the river to the main forks. He learned that the fork on the right had been ascended by a party of prospectors. Ascertaining from these men something of the country, he intended to take the more northerly or left-hand fork leading to a less known region and one concerning which information might be of greater value. Indians were found who had traversed these rivers in the winter, but who could give little information concerning the difficulties of summer travel.

One of the latest additions to the literature of Alaskan geography is contained in the bulletin of the Department of Labor for May, 1898. This has been prepared for the purposes of giving information relating to the opportunities for employment in the gold region. It consists largely of a narrative by Mr. Sam. C. Dunham of a trip undertaken by himself, under instructions from the Commissioner of Labor, beginning at Dyea on August 23, 1897. Besides the personal narrative, given in an interesting manner, are many general statements of the geography and condition of development of the country. With these are abstracts of statements from various individuals or officials met on the way, and sketch maps and views of important points.

The expedition of the Coast and Geodetic Survey to explore the mouths of the Yukon River has been delayed by difficulties of transportation and by not having at hand the light-draught boats,

which were built for the purpose of penetrating the waterways of the Yukon delta. These boats have been constructed in sections, and are being shipped to San Francisco, from which point they will be transported to the Yukon by the first available means. It had been planned to utilize the gunboat *Wheeling*, but on account of the war some other vessel must be taken.

No official chart has been made of the waterways leading from the ocean up to the main stream of the Yukon, and it is believed that a better channel than the one now used may be found. It is proposed to first go up this known channel and then attempt to work out in various directions to the outer bar, taking many soundings and carefully mapping the entire area.

Forestry in the Department of Agriculture.—On July 1 a change is to be made in the personnel of the Forestry Division of the Department of Agriculture, and probably also in the character of the work performed. Mr. Gifford Pinchot, who has been selected as chief of this important branch of investigation, possesses unusual qualifications for successfully conducting this work, combining the energy and adaptability of a native-born American with a thorough training and practical experience in forestry work. He was born in Connecticut in 1865. His ancestors on one side came over with the Plymouth Colony, and on both sides were engaged in the Colonial and Revolutionary wars. He prepared for college at Exeter and in New York, and graduated at Yale with the class of 1889, taking the DeForest medal, and later going abroad, where he took a course in the French forest school; later he travelled extensively in the German forests with Sir Dietrich Brandis, First Inspector-General of Forests to the Government of India. Mr. Pinchot's forest studies were directed by the latter. After seeing much of the methods of forest management in France and Switzerland and something of the same in Austria, he returned to America and began to visit and report upon various properties, giving especial attention to forest conditions in Arkansas, Georgia, North Carolina, Arizona, California, Oregon and Washington, and later in Pennsylvania and New York. In 1892 Mr. Pinchot took up what is considered to be the first instance of forest management in the United States; this was at Biltmore, North Carolina. He prepared the exhibits for the World's Fair at Chicago to represent the work in the Biltmore forest and the forest condition of the State of North Carolina. Later he became a member of the National Forest Commission, visiting the forests in Montana, Idaho, Oregon, California, Arizona and Colorado, making long trips with

pack trains or on foot. Upon the completion of this reconnaissance he was designated as the representative of the Secretary of the Interior, and in this capacity visited many of the national forest reserves, particularly the Flathead, Lewis and Clarke, Priest River, Washington, Olympic, and Black Hills. He thus enters upon his new duties with an understanding not only of methods abroad, but also of the conditions at home. With this wide view, it is to be assumed that he will be able to devise and suggest methods of forest management suited to present conditions of development rather than attempt merely to imitate what has been done in Europe.

It is anticipated that the results of the work of this division will be of wide geographic interest, as Mr. Pinchot's ambitions are to carry on the investigations in the forests rather than in the office, to know and make known the exact conditions of our woodlands, rather than to speculate about them; and finally he hopes to place before the people of the United States and the farmers practical suggestions which will lead to a larger and better utilization of the forest resources.

N.

RECORD OF GEOGRAPHICAL PROGRESS.

AMERICA.

WAR MAPS.—It cannot be said that, up to June 1, any of the war maps, with one exception, issued by the private map publishers in the United States, is of special value in following the events of the war. It is announced that about 500,000 copies of the most pretentious of these publications, a folio of sixteen pages, have been issued. It proves to be nothing but a hurried throwing together of old and highly colored plates. None of the points of prominence in the war is specially distinguishable. Not a coaling station of any nation is indicated, nor any of the cable lines which have been playing a prominent and, as at Cienfuegos, a tragical part in the war. The registering of colors is wretched and the results are most confusing. On the map of North America, for instance, our east coast towns appear to be fifty miles out in the Atlantic, and Havana and Matanzas are apparently on the south side of Cuba. Misinformation bristles on every page. If an attack on Cadiz, for example, should call special attention to that Spanish city, we should learn from the map of Spain in this production that Cadiz, which really stands on the point of a peninsula surrounded by water on three sides, is situated at the bottom of a land-locked bay. Such productions are beneath criticism.

The war has brought two excellent publications into view, the "Military Map of the Island of Cuba," issued by the War Department, in eight sheets, scale 1:250,000; and the smaller "military map of Cuba," in four sheets, scale 1:500,000 (about eight statute miles to the inch), also prepared in the Military Information Division of the War Department, and published by Julius Bien & Co., of this city. The information on this map is so detailed that any military campaign on the island may be intelligently followed by the general reader with its aid. It gives a good idea of topography and shows the footpaths and wagon roads as well as the few railroads. The same firm has issued an excellent map of the Philippines on a large scale mainly from Dutch and British sources.

THE BOTANY OF ALABAMA.—Dr. Charles Mohr, of Mobile, has for years been engaged in an investigation of the Botany of Alabama under the auspices of the State Geological Survey. One of

the results of his work is a volume now going through the press giving the complete flora of the State. This will be followed by a companion volume in which the useful and the noxious plants will be treated in a very thorough manner.

Climate and Commerce.—Mr. R. DeC. Ward gives an illustration in *Science* (No. 175) of the control of climate over commerce, and the modification of this control through human ingenuity. The closing of the large ports of Russia and Siberia by ice during the winter has been one of the serious drawbacks in the development of their import and export trade. But by means of huge steam rams it is now found possible to keep open many of the important harbors throughout the cold season. Vladivostok has a steam ram which keeps the ice from interfering with the utility of the harbor throughout the winter. The port of Hangö, in Finland, is also kept open by a steam ram, and Admiral Makarof, of the Russian Navy, thinks it perfectly feasible to maintain communication through the winter between the sea and the port of St. Petersburg.

Ice-breakers seem to offer equal advantages in Canada. The *Canadian Gazette* of Feb. 24th reports that an ice-breaker, constructed to run between Port aux Basques, the terminus of the Newfoundland Railroad, and Sydney, Cape Breton, has, pending the completion of the line, been put on the route from Placentia to Sydney, and has been running since November with unfailing regularity, breaking with ease through fifteen inches of solid ice, and keeping open the port of Sydney, which hitherto has been closed in winter.

EUROPE.

A Place of Refuge for Sealers in Barents Sea.—The *Izvestia* of the Russian Geographical Society reports (No. 4, 1898) the results of the expedition, sent in 1896 by the Hydrographic Department, to Novaya Zemlya to learn if good anchorage ground and a site for a settlement might be secured at Kostin Shar, the strait separating the south-west coast of the south island of Novaya Zemlya from Mezhdusharsky Island. A station there, it was believed, would stimulate the sealing and eider-down industries, the Government designing evidently to supply a place of succor and refuge similar to our station for the whaling fleet at Point Barrow. Bielusha Bay, penetrating the main land and near the west end of Kostin Shar, was selected and the place chosen for the station was named Samoyed. The place is easily reached from the ocean, and vessels surprised by storms on the inhospitable south-west shores of Novaya Zemlya may always find shelter there.

THE FOUNDER OF THE IMPERIAL RUSSIAN GEOGRAPHICAL SOCIETY.—The geographers of St. Petersburg have been celebrating the one hundredth anniversary of the birth of Count F. P. Lütke, who founded the Russian Geographical Society in 1845. His explorations in Novaya Zemlya and his geographical and other scientific observations during his trip around the world (1826–29) made him well known, and during his later life in St. Petersburg he was prominent in the circle of Russian men of science, who were wont to meet at the residence of one or another of the members for informal exchange of ideas on scientific topics. This circle of learned men came to be known as the "Academical Club" and, in its meetings, originated the idea of the Russian Geographical Society, which was realized by Count Lütke. The *Izvestia* says that the young Society had a hard struggle at first and its final success was mainly due to Lütke's energy and his accurate conception of the lines of practical usefulness along which it should labor. He was president of the Society and the later years of his life were largely devoted to its interests. He died in 1882, in his eighty-fifth year.

RECENT GROWTH OF THE PO DELTA.—The fact is well known that the Adriatic formerly extended farther to the west and at that time Ravenna and Adria were maritime towns, though now they are several miles from the sea. The recently calculated area of Italy shows an increase of land between Porto Buso, on the Austrian frontier and parallel of 44° 20′, north of the mouth of the Savio, of not less than 29.83 square miles, as compared with the measurement of 1884. With the object of ascertaining exactly where the extension of area has taken place, Professor Marinelli drew the line of the coast, as shown on the sheets of the new map, on that of 1883, and measured the enclosed areas with a planimeter. It then appeared that the movement in the outline of the coast has not been everywhere in the same direction, but that in some places the sea has gained on the land. As shown by Professor Marinelli's table (*Rivista Geogr. Italiana*, Ann. v. Fasc. 1), the total increment of land is 33.32 square miles, while the sea has spread over 3.49 square miles, reducing the gain of land to the 29.83 square miles set down above. Of this area 20.59 square miles are due to the alluvium of the Po itself.—(*Scottish Geog. Mag.*, May, 1898.)

HONORS FOR EXPLORERS PEARY AND HEDIN.—The Geographical Society of London has awarded one of its two Royal medals to R. E. Peary, C.E., U. S. N., for his explorations in northern Greenland, and the other to Dr. Sven Hedin for his work in Central Asia.

EXHAUSTIVE INVESTIGATION.—A rather exceptional illustration of the exceeding minuteness with which some Continental teachers and students conduct geographical investigations is afforded by the long paper of Dr. Josef Ritter Lorenz von Liburnau in his study of the Hallstätter Lake in the Austrian Alps. The area of the lake is less than nine square kilometers, and 218 closely printed pages in the *Mittheilungen* (Band XLI., No. 1 u. 2) of the Vienna Geographical Society are devoted to a microscopic consideration of every scientific aspect of this small body of water.

AFRICA.

DR. H. MEYER'S EXPEDITION TO KILIMA-NJARO.—After Meyer and Purtscheller had conquered Kilima-Njaro, the giant of African mountains, in 1889, it was hoped that other mountaineers would endeavor to carry out more detailed exploration of this highest point in Africa. Quite a number of travellers have visited the mountain since 1889, but none has succeeded in penetrating far into the snow region, though several attempts have been made. Dr. Meyer determined, therefore, to lead another expedition to the mountain for the purpose of completing the studies of his first expedition. He will leave Leipzig in June, accompanied by Mr. E. Platz, the painter and mountaineer of Munich. Dr. Meyer will give particular attention to the exploration of the north side of the mountain, and expects to make a topographic map of that part of Kilima-Njaro. Another important purpose is to study the evidences of former glaciation on the mountain. Several explorers in tropical South America, among whom are Sievers and Regel, have made a study of glacial traces at former periods and at comparatively low elevations. Similar observations have been made in tropical Africa on Ruwenzori by Scott Elliott and on Kenia by Dr. Gregory; and it is believed that similar studies on the greatest of African mountains will yield important results. Dr. Meyer will also give attention to the distribution of Alpine animal and vegetable life.—(*Petermanns Mitteilungen*, No. 4, 1898.)

DEPARTURE OF THE "WINDWARD."

About July 1st Civil Engineer R. E. Peary, U. S. N., will sail in the steam yacht *Windward* with an expedition which has for its avowed object the discovery of the North Pole.

To this task, which so many have set for themselves and which none have accomplished, Mr. Peary brings the ripest and most extended experience which has ever been brought to bear upon this problem.

During the twelve years which he has devoted to Arctic discovery and exploration his successes have come from the energetic execution of bold plans carefully laid, and though the results attained have been almost unparalleled, they have been reached without loss of life and without extraordinary hardship.

His failures, on the other hand, have overtaken him when he departed from his own clear and logical plans.

In the *Windward* Peary will, after coaling at Sydney, C. B., push on to Inglefield Gulf, his former headquarters, where he will take on board six or eight families of Eskimos—all picked individuals—together with a large supply of walrus meat, to be used later as dog food. Then steaming through Smith Sound, Kane Basin, Robeson and Kennedy channels, he will endeavor to reach Sherard Osborn Fjord, where the *Windward* will land him with his surgeon, his colored man Matthew Henson and his band of Eskimos, with dogs, sledges, equipment, etc., etc.

The ship will then come home if she succeeds in escaping the ice floes, or, if nipped, will winter in the ice wherever caught and come south in the Spring of 1899.

It is understood that while Sherard Osborn Fjord is Peary's objective point at present, he will, if the ice-conditions admit of it, steam still farther north before disembarking, or, if the season is against him, he may be forced to send the ship back before reaching Sherard Osborn Fjord.

Wherever he may land he will at once begin his journey northward, travelling Eskimo fashion with all his household goods on a dog-sledge. In fair weather he will advance steadily along the coast, travelling by the light of the stars and moon, sleeping sometimes in tents, sometimes in snow houses, sometimes in the open under the lee of his sledges.

In this way he hopes to reach the northernmost extremity of Greenland in the early summer of 1899. Then with a band of seasoned companions and trained dogs from which to select the fittest, he will equip a small compact party and start over the sea-ice toward the Pole, hoping to reach that point and return to the land before winter begins again.

Returning southward during the winter of 1899–1900 he will, if necessary or advisable, follow his old route over the ice-cap to Inglefield Gulf.

If the summer of 1899 should prove to be unfavorable, either in weather or in ice-conditions, Peary will establish his Eskimo colony at the northern end of Greenland and, if necessary, wait for the summer of 1900 or 1901.

In the meantime the *Windward* will go as far north as possible each summer, and leave fresh supplies at certain pre-determined points.

This, in brief, is Mr. Peary's plan. Of the men and equipment selected to carry it out it may be stated that every man, as well as every article of the outfit, might justly be stamped: "Tried and found to be satisfactory."

Beginning with the ship, we have the staunch sealer presented to Mr. Peary by Alfred G. Harmsworth, Esq., of London. In her famous trips to and from Franz Joseph Land in connection with the Jackson-Harmsworth Expedition the *Windward* established her reputation for solidity.

To command so worthy a ship Mr. Peary has secured the services of an equally worthy master. Capt. John Bartlett, of Newfoundland, took the Bradford-Hayes Expedition north in the *Panther* as long ago as the sixties, and since 1895 he has been ice-master on the Peary expeditions of 1895–96 and '97.

The surgeon will be a new man, but Henson is second only to the Eskimos in experience of arctic life and methods of travel.

In the way of equipment and supplies Peary carries no superfluous material, but only such articles as he has found by previous experience to be reliable and of value.

His plans command the approval of all good judges, and he sets forth upon his enterprise with the heartiest good wishes.

E. D.

MAP NOTICES.

Since the publication of the last Bulletin, the U. S. Geological Survey has issued seven additional sheets of the United States atlas. Of these, one in southern New Hampshire, known as Monadnock, represents an area of 15″ square, upon a scale of 1:62,500, with a contour interval of 20′. It is a part of the hill country of New England, where the work of erosion has not progressed nearly as far toward producing a peneplain as near the coast. Many isolated hills, differing greatly in altitude, are scattered over this area, among them Mount Monadnock, the highest in the neighborhood, which occupies a central position upon the sheet. The effect of the recent elevation and tilting of this region is shown in the cañons of many of the streams, while the still more recent invasion of the land by ice is shown in the abundance of lakes and ponds, waterfalls and rapids, and irregularities in the courses of the minor streams.

In New York are two sheets, Newcomb and Olean, the former in the Adirondacks, and the latter in the southwestern portion of the State. Both are on a scale of 1:62,500, with a contour interval of 20′. The first represents an area very similar in its physiographic features to that above described, being a region of isolated, broken hills or monadnocks, as they have been denominated by Davis, with the streams flowing mainly in deep, newly cut cañons, consequent on the recent tilting and elevation of the land, with an abundance of lakes, ponds and swamps, rapids and falls, due to the erosive action of the continental glacier.

The Olean area is a portion of the great Alleghany plateau, the westernmost member of the Appalachian mountain system, a region which was base-leveled upon a surface of a bed of hard, carboniferous sandstone, thus forming a plateau. This was raised and tilted, the tilting here being toward the west, and the subsequent erosion has gone so far as to produce deep, narrow valleys along the streams, but has had little effect upon the general level of the plateau.

In South Dakota is one sheet, Parker, representing an area of 30″ square, upon a scale of 1:125,000, with a contour interval of 20′. In the main its surface has been produced by the deposits of the great continental glacier, the southwestern part being occupied largely by an arm of the Coteau des Prairies, a plateau-like deposit of morainal material rising some 200′ above the general level. The

principal streams, Vermilion and James rivers, have been in existence so short a time that they have done but little erosion; the latter stream having cut its bed only about 100′ below the general level of the country. The region abounds in swamps and lakes without outlet, the result of glacial occupation.

In Nebraska are two sheets, Grand Island and Camp Clarke, both upon a scale of 1 :125,000 and with a contour interval of 20′. The former includes a portion of the valley of Platte River, here having a breadth of upwards of 20 miles, almost as level as a billiard table. The river is represented as at low water, consisting of a number of petty trickling streamlets scattered widely over its bottom. Southeast of the river the land rises in low bluffs covered with sand hills, in which are numerous sinks. The divide between the waters of the Platte and the Republican is here within a mile or two of the former stream.

The Camp Clarke sheet represents an area in western Nebraska traversed by North Platte River, which here, even at the time of low water, is a bold stream, having a width of fully half a mile, flowing through a bottomland five or six miles in width. North of it the country rises brokenly to a high prairie five hundred feet above the river. Much of its summit is covered with small sand hills, which make the soil valueless, except for purposes of grazing. South of the river, and separating it from Pumpkin Creek, are soft sandstones, highly eroded, forming bad lands. Many of the curious rock forms in this region are well known as landmarks, among them Chimney, Castle and Steamboat rocks. South of Pumpkin Creek the land rises gradually and then abruptly to a high prairie, similar to that upon the north side of the Platte.

In California is one sheet, Mount Diablo, upon a scale of 1 :62,500, and with a contour interval of 50′. This sheet represents an area in the coast ranges east of the Bay of San Francisco and south of Sacramento River.

A special map has been published of the surroundings of Hot Springs, Arkansas, upon a scale of 1 :62,500, with a contour interval of 20′. This presents in much detail the peculiar sinuous ridges of the Ozark hills.

The war with Spain continues to furnish a stimulus to map publishers. Among the useful maps to which attention may be called is that published by the Hydrographic Office, U. S. N., entitled "The Island of Cuba," on a scale of 10 miles to 1″. This map, although upon a much smaller scale than that of the War Department, noticed in our last number, has the advantage of exhibiting at once not only the land features, but the depths of water, both off shore and in the harbors. H. G.

"*Our New Colonies—Cuba, Porto Rico and the Philippines, J. L. Smith, Philadelphia, 1898.*" This is a popular and cheap map, combining representations of all these islands upon one sheet.

It is astonishing how completely all interest in the gold fields of Alaska has disappeared, and it is, therefore, with a feeling akin to surprise that we are recalled to it by receiving the "Yukon Map." This map, in ten sheets, represents all that is known of the country from Cook Inlet, by way of the several Yukon trails to the United States boundary on the Yukon; the scale, 6 miles to 1", 1898, prepared and published by the General Surveyor's Office, Department of the Interior, Ottawa. Relief is expressed by sketchy contours and by crayon shading. H. G.

The Century Atlas of the World, prepared under the Superintendence of Benjamin E. Smith, A.M., Century Company, New York, 1897. 4to. Map Plates 117, with Indices.

The question is often asked, "What is the best atlas of the world?" While it may not be strictly correct to answer "The Century," certainly this is as good as the best, especially for American use. Of the whole number of plates, 53, or nearly one-half, are devoted to the United States, 5 to Canada, 9 to Central and South America, 27 to Europe, 9 to Asia, and an equal number to Africa and Australia together. The remainder of the Atlas is devoted to historical maps of Europe, Asia Minor and the United States, and to physical maps of the world.

The maps are well executed, clear, legible, leaving little or nothing to be desired on that score. They are thoroughly up to date and sufficiently full of detail for all ordinary requirements. The maps are well indexed. H. G.

Physiographic Types, by Henry Gannett. Topographic Atlas of the United States. Folio 1, U. S. Geological Survey, Washington, D. C., 1898.

We welcome Folio 1 of the Topographic Atlas of the United States, recently published by the United States Geological Survey, for it marks a distinct step in advance in educational geography. Hitherto the teachers of physiography in High Schools, Academies and Colleges have been unable to make the best use of the valuable maps of the United States Geological Survey, because not readily available, and because when secured no adequate descriptive text accompanied the maps. Now we have a selected series of ten maps, representing typical and simple land forms of the United States,

brought together in one folio, with good text descriptions. Furthermore, the folio is uniform in size and style with the geological folios, a matter of help to librarians and teachers having to care for large collections.

The folio opens with a summary of the history of map making by the United States Geological Survey, followed by a description of a topographic map, under the headings, scale, sheets, contents, water features, culture and land features. The sheets selected for description are the following: Fargo, North Dakota-Minnesota; Charleston, West Virginia; Caldwell, Kansas; Palmyra, Virginia; Mount Shasta, California; Eagle, Wisconsin; Sun Prairie, Wisconsin; Donaldsonville, Louisiana; Boothbay, Maine; Atlantic City, New Jersey. "The ten sheets here described illustrate the operation of water and ice in the production of topographic forms, under simple conditions. The first three show different stages of progress in aqueous erosion—the beginning, middle, and a late stage. The fourth sheet shows how the process of aqueous erosion, having been carried far toward completion, may commence again. The fifth sheet shows the growth of a volcanic mountain and the commencement of its destruction. The sixth and seventh sheets illustrate glacial deposition; the eighth, river deposition; and the ninth and tenth, the formation of coast lines."

The examples selected are simple, clear and extremely valuable. Although primarily for use in the secondary schools and colleges, we know from experience that many of the maps can be made of great value in the graded schools. For instance, the Donaldsonville sheet, selected to illustrate river flood plains, will, when carefully studied, give children of eleven and twelve years ideas of the possibilities of floods and their effects such as any amount of reading would not so emphasize.

To be of greatest service the maps must, however, be studied individually at desks, for topographic maps cannot be used readily as wall maps.

We are glad to note that a second folio on the Physiography of Texas is in press, and a third under way. We hope that the response of teachers and superintendents may warrant the continuation of the series, and that these folios may soon be found in all our best schools.

The folio thus reviewed may be secured for twenty-five cents from the Chief Clerk of the U. S. Geological Survey, Washington, D. C. R. E. D.

BOOK NOTICES.

Northward Over the "Great Ice." A Narrative of Life and Work along the Shores and upon the Interior Ice-Cap of Northern Greenland in the Years 1886 and 1891–1897. With a Description of the Little Tribe of Smith-Sound Eskimos, the most Northerly Human Beings in the World, and an Account of the Discovery and Bringing Home of the "Saviksue," or Great Cape York Meteorites. By Robert E. Peary, Civil Engineer, U. S. N., Member of the American Society of Civil Engineers, Member of the American Geographical Society. With Maps, Diagrams, and About Eight Hundred Illustrations. In Two Volumes. New York. Frederick A. Stokes Company. MDCCCXCVIII.

In the author's words, this narrative has been written to supply a complete authentic record of his Arctic work—a record which he owed it to his family, his friends and himself to put in permanent form.

The narrative covers the reconnaissance of the Greenland Inland Ice in 1886; the thirteen-months' sojourn in North Greenland in 1891–92, including the twelve-hundred-mile sledge journey across the ice-cap and the determination of the insularity of Greenland; a twenty-five months' stay in North Greenland in 1893–95, with a second 1200-mile sledge journey over the ice-cap, the completion of the study of the Whale-Sound natives, a survey of that region and the discovery of the Cape York meteorites; and the summer voyages in 1896 and 1897, with the story of the removal of the 90-ton Cape York meteorite.

Mr. Peary recognizes in the fullest sense his obligation to the Societies and to the friends, who have stood ready through twelve years to help him with influence and with means, and to the Government which has kindly given to him the leave of absence for his Arctic work; but he rightly calls attention to the fact that his work has been accomplished by private enterprise, and that fully two-thirds of the total cost have been furnished by himself. Single contributions from other sources have never exceeded $1,000, except when Mr. Morris K. Jesup, President of the American Museum of Natural History, bore the principal burden of the expedition which brought back Peary and his two companions in 1895.

It is not to be doubted that the idea of utilizing the Inland Ice as a road for overland sledge journeys belongs to Mr. Peary, and that he has introduced the design for winter quarters, the use of the odometer, the barograph and thermograph, and has shown that the explorer in the Arctic may dispense with the sleeping-bag.

Even those, who do not feel the attraction of his main subject, must take a deep interest in Mr. Peary's account of the Eskimos of Cape York, that isolated community of 253 persons, the outpost of the human race in the far North.

The effect of his expeditions upon the comfort of these people is strikingly put:

> Seven years ago, many a man in this tribe possessed no knife, and many a woman no needle. Few of the men possessed kayaks, or skin canoes; and he was indeed well off who had a spear- or harpoon-shaft made of a single piece of wood. To-day, men and women are amply supplied with knives and needles; every adult man and half-grown boy has his canoe; most of the men have guns; and every hunter is supplied with the best of wood for his lance, his harpoon, his seal-spear, and his sledge. The effect of these improvements in their weapons has shown itself at once in an improved condition of the tribe, resulting from the great increase in the effectiveness of the hunters. The people are better clothed, they can support a larger number of dogs (their only domestic animal) and, as a result of their more ample nourishment, and consequent greater ability to withstand the constant hardships of their life, the death-rate has decreased, and the birth-rate perceptibly increased, within the past six years.

The detailed study of these Eskimos has not been attempted in this work. The chapter devoted to them (Vol. 1, pp. 479–514) presents no more than a brief condensation of the material in Mr. Peary's hands. None the less, it is full of interest.

Mr. Peary is inclined to accept Sir Clements Markham's theory concerning the Siberian origin of the Eskimos, a theory which receives some support from their physical peculiarities; and he tells us that "Miss Bill," the young girl brought to this country in 1894 by Mrs. Peary, when she met a Chinaman, ran up to him and tried to talk with him, and that members of the Chinese Legation in Washington spoke to her as to one of their countrywomen. These are incidents to be noted, but it is easy to overrate their importance and to mistake their significance.

There is no form of government among the Arctic Highlanders. Each man is supreme in his family, and each family is self-supporting. There is no marriage ceremony, and the wife is a piece of property, like a sledge or a canoe. At the same time, children and the infirm and aged are kindly treated.

They seem to have, properly speaking, no religion; but decision must be reserved on this point.

They are generally below the average stature, though some of the men are about five feet ten inches in height, and all are plump and solidly built. Their muscular development is astonishing, concealed as it is under the covering of blubber which they possess, in common with the seal, the walrus and the bear.

These children of nature have no depraved habits, no stimulants, no narcotics, no slow poisoning; or, in one word, no medicine.

They practise no mutilation. Their diseases are principally rheumatism and lung and bronchial troubles.

Contrasting these uncontaminated people with their relations in South Greenland, protected though these have been by the vigilance of the Danish Government, Mr. Peary hopes that they may be left in peace to live out the part appointed them by the Creator, undisturbed by efforts to understand the white man's ideas of God, of right and of morality.

Mr. Peary wins his reader from the beginning, with the directness and the unstudied flow of his story, already familiar in outline to geographers throughout the world, but set before them now afresh with the earnestness and the vitality of a sustained purpose.

His exploration of the Greenland ice-cap, with all its peculiar conditions, was a new contribution to the knowledge of the Arctic, and a chapter added to the history of heroic endeavour. It is not to be thought that he has said his last word; but whatever may be the outcome of the years before him, his place is already won among the simply great, the

> strong in will
> To strive, to seek, to find, and not to yield.

Physiography for Beginners, and Physiography for Advanced Students. A. T. Simmons, The Macmillan Co., 1897.

The two books whose titles are given above have to do with physiography in the English and not the American sense. They are thus largely devoted to the elements of physics and chemistry, to mathematical and astronomical geography, and very different in character from our better text books in geography for secondary schools that we have in this country. They are neither of them available for students' use in this country, because too inclusive, and because much of the subject matter would here be given in elementary courses in other subjects.

They are, however, both very suggestive to a teacher, and well worthy of adoption as reference books. The experiments are well selected, and the diagrammatic illustrations very suggestive and to the point. In some cases the arrangement and plan of development

might well be questioned as to the pedagogical value. For instance, a much better treatment of the ocean currents would be to give first the paths of the currents as they must be in a general way on a rotary globe, with the axis inclined 23½ degrees. The actual condition in each ocean could then be compared with the conditions determined by the position of the planet in space, and thus each ocean would not be a unit. In the same way we miss the more scientific classification of winds as given in our better text books, and the more modern conception of that difficult problem of the "tide opposite the moon."

The books are much more mathematical and exact than the books of a similar character with which we are familiar, and might be made the basis for some very carefully planned and accurate laboratory work in the field they cover. We wish that some of the manner of treatment adopted by Mr. Simmons might be followed more extensively with us. R. E. D.

Geography in the Educational System of Great Britain.

In 1885, Dr. J. Scott Keltie, now Secretary of the Royal Geographical Society of London, and editor of the *Geographical Journal*, presented to the Council of the Society a very full and careful report on the position of geography in the educational system of Great Britain. This report marked a great step in advance in geography teaching in Great Britain, and has been the ultimate reference book on the subject since.

At the Toronto meeting of the British Association in 1897, a committee of six presented a long report, based on Dr. Keltie's earlier labors, and bringing the matter of geography in education up to date. The report was mainly prepared by the Secretary of the Committee, Mr. Andrew J. Herbertson, of Heriot-Watt College, Edinburgh, and deserves careful reading by all interested in the subject. It covers 38 pages in the report of the British Association for 1897.

The report considers the subject of geography in all grades of educational work, and contains illustrations of syllabi and examination papers. It is very interesting to note that one of the generalizations made by the Committee is in reference to the failure of most pupils to gain knowledge of geographical *principles* from their school work. This failure is unfortunately very widely true in this country also. R. E. D.

ACCESSIONS TO THE LIBRARY.

MAY–JUNE, 1898.

BY PURCHASE.

London Street Names, by F. H. Habben, Philadelphia, 1896, 8vo ; Notes on the Nicaragua Canal, by Henry I. Sheldon, Chicago, 1897, 8vo ; The Navigation and Voyages of Lewis Wertomannus, etc., 1503, translated by Richarde Eden, Edinburgh, Aungervyle Society, 1884, 8vo ; Military Map of Puerto Rico, 1898, War Department, Washington (New York), 1898, sheet ; The Naturalists' Directory, by S. E. Cassino, Boston, 1898, 16mo ; The Journal of Jacob Fowler, etc., edited, with Notes, by Elliott Coues, New York, 1898, 8vo; Archæological Survey of India, Reports, Vols. 1–23, and General Index, Simla and Calcutta, 1871–1887, 24 vols., 8vo ; Journal ou Description du Merveilleux Voyage de Guillaume Schouten, etc., Amsterdam, 1619, 4to ; Travels through the Western Country in the Summer of 1816, by David Thomas, Auburn (N. Y.), 1819, 12mo ; Biographies of Words and the Home of the Aryas, by F. Max Müller, London, 1888, 8vo ; Voyage à Constantinople, etc., par Boucher de Perthes, Paris, 1855, 2 vols., 12mo ; Map of the Philippine Islands and Adjacent Seas, New York, 1898, folded in book ; Trinidad and the Other West India Islands and Colonies, by Daniel Hart, Trinidad, 1866, 8vo; History of the Gipsies, by Walter Simson, edited by James Simson, New York, 1866, 12mo ; The Azores: or Western Islands, by Walter Frederick Walker, London, 1866, 8vo; The Punjab and Delhi in 1857, by J. Cave-Browne, Edinburgh, 1861, 2 vols., 8vo ; Borneo and the Indian Archipelago, by Frank S. Marryat, London, 1848, 8vo; Les Races et les Nationalités en Autriche-Hongrie, par Bertrand Auerbach, Paris, 1898, 8vo ; Cinq Mois au Pays des Somalis, par le Prince Nicholas D. Ghika, Bale et Genève, 1897, 8vo ; American Annals, or a Chronological History of America, by Abiel Holmes, Cambridge, 1808, 2 vols., 8vo ; Life and Adventures of Peter Wilkins, by R. S. (Robert Paltock), Boston, 1833, 32mo ; Harem Life in Egypt and Constantinople, by Emmeline Lott, Philadelphia (s. a.), 16mo; The World in Miniature, Illyria and Dalmatia, edited by Frederic Shoberl, London, 1820, 2 vols. in 1, 12mo; Description of Latium (by Cornelia Knight), London, 1805, 4to ; New Geographical Dictionary, etc., London, 1738, 8vo; The Jesuit Relations and Allied Documents, edited by Reuben Gold Thwaites, Vols. XIX, XX, Cleveland, 1898, 8vo ; The Archer and the Steppe, by F. R. Grahame, London (1860), 8vo ; The Riviera, by Hugh Macmillan, London, 1892, 8vo ; The Travels of a Hindoo to Various Parts of Bengal and Upper India, by Bholanauth Chunder, London, 1869, 2 vols., 8vo ; Carthage and the Carthaginians, by R. Bosworth Smith, London, 1878, 8vo ; Mohammed and Mohammedanism, by R. Bosworth Smith, 2d edition, London, 1876, 8vo ; Narrative of an Official Visit to Guatemala from Mexico, by G. A. Thompson, London, 1829, 8vo ; Lands of the Slave and the Free, by H. A. Murray, London, 1857, 8vo; Sketches of Bermuda, by Susette Harriet Lloyd, London, 1835, 8vo ; Northward over the "Great Ice," by Robert E. Peary, New York, 1898, 2 vols., 8vo; Considerations Sanitaires sur l'Expédition de Madagascar, etc., par le Dr. G. A. Reynaud, Paris (1898), 18mo ; L'Algérie-Le Sol et les Habitants, par J.-A. Battan-

dier et L. Trabut, Paris, 1898, 16mo; A Journal of the First Voyage of Vasco da Gama, 1497–1499, translated, etc., by E. G. Ravenstein (Hakluyt Society), London, 1898, 8vo; A Sketch of Chinese History, etc., by Charles Gutzlaff, New York, 1834, 2 vols., 12mo; My Early Travels and Adventures in America and Asia, by H. M. Stanley, New York, 1895, 2 vols., 8vo; A Faggot of French Sticks, by Francis Head, London, 1852, 12mo; At Home in Paris, by W. Blanchard Jerrold, London, 1864, 12mo; Memoir of Sir Andrew Crombie Ramsay, by Sir Archibald Geikie, London, 1895, 8vo; Life in Tuscany, by Mabel Sharman Crawford, Columbus, 1859, 8vo; Russia As It Is, by A. de Gurowski, New York, 1854, 12mo; The Paris Sketch Book, by William M. Thackeray, New York, 1858, 12mo; Home Sketches in France, by Mrs. Henry M. Field, New York, 1875, 12mo; Letters from the Bye-Ways of Italy, by Mrs. Henry Stisted, London, 1845, 8vo; Pausanias's Description of Greece, translated, with a Commentary, by J. G. Frazer, London, 1898, 6 vols., 8vo; Deshasheh, 1897, by W. M. Flinders Petrie (Fifteenth Memoir, Egypt Exploration Fund), London, 1898, 4to; Explanatory Text of a Geological Map of the United States, by Jules Marcou, Boston, 1853, 8vo; The Mariner's New and Complete Naval Dictionary, by J. W. Norie, 3d edition, London, 1804, 8vo; Travels in South Africa, etc., Narrative of a Second Journey, by the Rev. John Campbell, London, 1822, 2 vols. in 1, 8vo; History of New Mexico, 1530–1890, by Helen Haines, New York, 1891, 8vo; Sketches in Modern Paris (by A. Ebeling), translated by Frances Locock, London, 1870, 8vo; The Naval Apprentice's Kedge Anchor, or Young Sailor's Assistant, by William Brady, New York, 1841, 12mo; The Watering Places of the Vosges, by Henry W. Wolff, London, 1891, 8vo; A Voyage of Discovery, etc., in H. M. Ships Isabella and Alexander, etc., by John Ross, 2d edition, London, 1819, 2 vols., 8vo; History of Harvard University, by Josiah Quincy, Boston, 1860, 2 vols., 8vo; De l'Allemagne, par Madame de Staël, Paris, 1847, 8vo; A Residence in France, by J. Fenimore Cooper, Paris, 1836, 8vo; Paris Guide, La Science–L'Art–La Vie, Paris, 1867, 2 tomes, 8vo; Two Years in the French West Indies, by Lafcadio Hearn, New York, 1890, 12mo; Modern Frenchmen, by Philip Gilbert Hamerton, Boston, 1878, 8vo; Scenery of the Rhine, Belgium and Holland, by Capt. Batty, London, 1826, 8vo; The Church of Sancta Sophia, Constantinople, by W. R. Lethaby and Harold Swainson, London, 1894, 8vo; Comisión del Mapa Geológico de España: Boletín, Tomos VII–XXI, 8vo; Memorias, 11 Tomos, 8vo; Atlas (62 sheets); Mapa (1 sheet), Madrid, 1880–1896; Spain As It Is, by G. A. Haskins, London, 1851, 2 vols., 8vo; The Gypsy Road, a Journey from Krakow to Coblentz, by Grenville A. J. Cole, London, 1894, 8vo; The Book of Wonder Voyages, edited by Joseph Jacobs, New York, 1896, sq. 8vo; A Perpetual Calendar, with Notes, etc., by L. S. F. Pinaud, Albany, 1896, 8vo; Map of the Original Grants of village lots from the Dutch West India Company to the Inhabitants of New-Amsterdam, etc., Grants commencing A. D. 1642, located by Henry D. Tyler, New York, 1897, sheet; A Plan of the City of New York from an actual Survey, by William Bradford (The Bradford Map), 1728, fac-simile by Henry D. Tyler, New York, s. a., sheet; A Description of the Towne of Mannados, or New Amsterdam (The Duke's Plan), 1661, fac-simile by Henry D. Tyler, New York, s. a., sheet; Life, Letters, and Works of Louis Agassiz, by Jules Marcou, New York, 1896, 2 vols., 8vo; The Law of Nations, etc., by Travers Twiss, Oxford, 1861–1863, 2 vols., 8vo; Flags of Maritime Nations, 5th edition, Washington, 1882, 4to; The English Catalogue of Books, compiled by Sampson Low, Vol. II, 1863–1871, London, 1873, 8vo; Index to the English Catalogue of Books, Vol. II, 1856–1875, Vol. IV, 1881–1889, London, 1876–1893, 2 vols., 8vo.

GIFTS.

From the American Book Company, New York :

Natural Advanced Geography, by Jacques W. Redway and Russell Hinman, New York (1898), 4to.

From the Capitaine Alfred Bertrand, Author :

Au Pays des Ba-Rotsi, Haut-Zambèze, Paris, 1898, 8vo.

From the Central Committee of the Da Gama Centenary, 1898, Lisbon :

Vida do Abba Daniel (Ethiopica e Portugueza), por L. Goldschmidt e F. M. Esteves Pereira ; Como Se Perdeu Ormuz, por Luciano Cordeiro (Ed.) ; Religiões da Lusitania, por J. Leite de Vasconcellos, vol. 1 ; Dai-Nippon (O Grande Japão), por Wenceslau de Moraes ; Chronica dos Reis de Bisnaga, por David Lopes (Ed.) ; Dos Feitos de D. Christovam da Gama, por Miguel de Castanhoso ; A Viagem da India, Poemeto por Fernandes Costa ; Hymno do Centenario da India, por Fernandes Costa ; Vasco da Gama e A Vidigueira, por A. C. Teixeira de Aragão ; Textos em Aljamía Portuguesa, por David Lopes (Ed.) ; No Oriente-De Napoles á China, por Adolpho Loureiro, 2 vols. ; O Centenario no Estrangeiro, por Magalhães Lima. (In all, 13 vols., Lisboa, 1896–1898, 8vo.)

From the Chamber of Commerce, New York :

Fortieth Annual Report, New York, 1898, 8vo.

From Chas. P. Daly :

Kaart der Stroomvaartdiensten (Indian Archipelago), Amsterdam, 1898, sheet. (Supplement, April 30, Indische Mercuur.) ; Hydrography of Sicily, Malta and Adjacent Isles, by Wm. Henry Smyth, London, 1823, folio ; Engraved portrait of Amerigo Vespucci, by Francesco Allegrini, 1762.

From the Publisher of The Independent, New York :

Map of Africa, changes of Half a Century, drawn and engraved for The Independent, 1898.

From the Lawyer's Club, New York :

The Lawyer's Club (New York), 1898, 4to.

From Oscar Leal e Cyriaco de Nobrega, Authors :

Um Marinheiro do Seculo XV., Funchal, 1898, 16mo.

From Carl Lumholtz :

Marked Human Bones from a Prehistoric Tarasco Indian Burial Place in the State of Michoacan, Mexico. By Carl Lumholtz and Aleš Hrdlička, Author's edition, extract from Bulletin Am. Mus. Nat. Hist., New York, 1898, p. 8vo.

From R. E. Peary, C.E., U. S. N.:

Photograph portrait of himself.

From E. L. Plumb:

Chart of Manila Bay, U. S. Hydrographic Office, Washington, 1890 (Corrections, January, 1898), sheet.

From Dr. Ludwig Schmidt, Bibliothekar an der Königlichen öffentlichen Bibliothek zu Dresden :

Kurfürst August von Sachsen als Geograph. Ein Beitrag zur Geschichte der Erdkunde, von Dr. Ludwig Schmidt. Dresden, 1898, 4to.

NOTES AND NEWS.

The Fourth Centenary of the discovery of the maritime route to India has been worthily celebrated. The Paris Geographical Society held a special Vasco da Gama meeting on the 25th of April, opened by an address from the President, M. A. Milne-Edwards. He was followed by Prof. Henri Cordier, who spoke of the Relations between Europe and Asia before and after the voyage of the great Portuguese; by Lieut. Emile Védel, who described the voyage as recorded in the *Roteiro;* and by the Marquis de La Mazelière, who took for his subject India at the Time of Vasco da Gama.

At a special meeting of the Royal Geographical Society, held on the 16th of May, the President, Sir Clements Markham, K.C.B., read a paper on The Four Hundredth Anniversary of the discovery of the Cape Route to India by Vasco da Gama.

At Lisbon the celebration was opened, May 17th, by the firing of a salute of 101 guns by the forts and ships, and a grand naval review of the Portuguese and foreign ships. The three following days were devoted to regattas, processions, exhibitions and meetings, varied by excursions to famous places, such as Cintra, Batalha, Coimbra and Oporto.

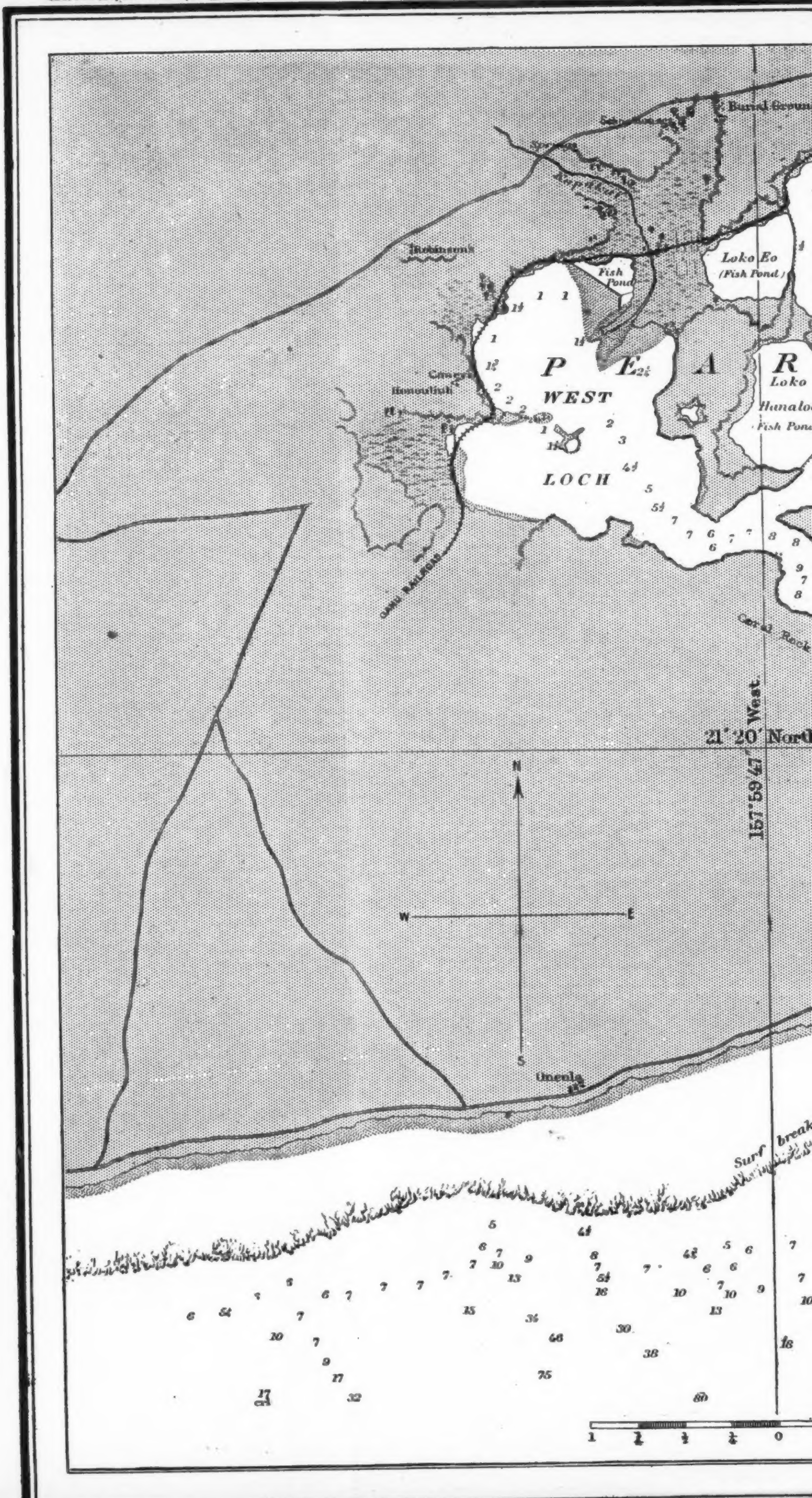
Besides the publications of the Central Executive Committee (elsewhere acknowledged), and those of the Lisbon Geographical Society and the *Revista Portugueza Colonial e Maritima*, an Album Commémoratif has been brought out in Paris by Mme. Juliette Adam, in a handsome folio, containing original poems, drawings and compositions, literary and musical, by François Coppée, Vice-Admiral Gervais, Carolus Duran, Puvis de Chavannes, Saint-Saëns, Sully-Prudhomme, Pierre Loti and others.

Another work forms a more permanent contribution to the literature of the Centenary. This is Mr. E. G. Ravenstein's translation of the *Roteiro*, issued by the Hakluyt Society, as No. XCIX. of their series. In this the editor has added translations of the letters of King Manoel and Sernigi and of three Portuguese accounts of da Gama's voyage. His Introduction and Notes are very valuable, though the reader learns with surprise (*Introduction, p. XV.*) that Magellan was a renegade Portuguese, and that the feminine form of the Latin adjective *vetus* is *veta* (*Introduction, p. XXV.*)

The *Université Nouvelle de Bruxelles* founded, on the 18th of March of this year, a Geographical Institute and adopted a plan of instruction comprising a Preparatory Course in the elements of science, of history, of languages and of drawing, and a three years' Higher Course, with excursions during the vacations. The Institute expresses the wish to establish relations with geographical societies. Communications are to be addressed: au Secrétariat général de l'Université Nouvelle, rue des Minimes, 21, à Bruxelles.

The Siebenbürgischer Verein für Naturwissenschaften, at Hermannstadt, announces the death, on the 26th of May, of Dr. Edward Albert Bielz, one of the founders and for many years presiding officer of the Verein.

crl. *coral*, m. *mud*, s. *sand*, wh. *white*.



SOUNDINGS IN FATHOMS.